Monitoring activities in support of endangered Atlantic Whitefish (*Coregonus huntsmani*) recovery efforts in the Petite Rivière lakes in 2013

D. E. Themelis, R.G. Bradford, P.H. LeBlanc, S.F. O'Neil, A.P. Breen, P. Longue and S.B. Nodding

Population Ecology Division
Fisheries and Oceans Canada
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

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D.E. Themelis, R.G. Bradford, P.H. LeBlanc, S.F. O'Neil, A.P. Breen[1], P. Longue[1]
and S.B.Nodding[1]

Fisheries and Oceans Canada
Bedford Institute of Oceanography
P.O. Box 1006
1 Challenger Drive
Dartmouth, NS B2Y 4A2

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[1] Bluenose Coastal Action Foundation, Lunenburg, Nova Scotia, B0J 2C0

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TABLE OF CONTENTS

ABSTRACT iv
RÉSUMÈ iv
PREFACE v
INTRODUCTION 1
PART 1. MONITORING ACTIVITIES IN UPPER PETITE RIVIERE WATERSHED 1
  HEBB DAM 1
    Spring 2013 Monitoring (May-June) 2
    Fall 2013 Monitoring (October - November) 3
HEBB LAKE (BELOW MILIPSIGATE DAM) 4
    Floating Trap Net (May - June) 4
    Seining (October 3rd) 5
  MINAMKEAK LAKE 5
    Floating Trap Net (September-October) 5
PART 2. FISH HEALTH SCREENING 6
PART 3. SURVEY OF INVASIVE SPECIES IN PETITE RIVIÉRE WATERSHED 7
  EXPLORATORY ANGLING SURVEYS (*April-October*) 7
    Smallmouth Bass 7
    Chain Pickerel 7
  VARIOUS FIXED GEAR (April-June) 8
  BOAT ELECTROFISHING (Mid-July) 8
    Milipsigate Lake Sampling (July 15-16) 8
    Minamkeak Lake (July 17-18) 9
  SIZE COMPOSITION OF INVASIVE SPECIES 10
SUMMARY 10
REFERENCES 11
TABLES 13
FIGURES 21
APPENDIX 1: HEBB LAKE DAM INTERIM MONITORING PLAN UPDATE 41
APPENDIX 2. QUALITATIVE RISK REVIEW 63
APPENDIX 3. FISH HEALTH SCREENING RESULTS 91
APPENDIX 4. SPECIES CAPTURED BY BOAT ELECTROFISHER 93

ABSTRACT

Themelis, D.E., Bradford, R.G., LeBlanc, P.H., O'Neil, S.F., Breen, A.P., Longue, P., and Nodding, S.B. 2014. Monitoring activities in support of endangered Atlantic Whitefish (*Coregonus huntsmani*) recovery efforts in the Petite Rivière lakes in 2013. Can. Manuscr. Rep. Fish. Aquat, Sci. 3031. v + 94 p.

General status and distribution of the remaining wild populations of the endangered Atlantic Whitefish (*Coregonus huntsmani*) were monitored in 2013 in three small inter-connected lakes, Hebb, Milipsigate and Minamkeak, in the upper Petite Rivière watershed, Lunenburg County, in southwestern Nova Scotia. Activities included daily sampling of fish migrating through the fishway at Hebb Dam in spring and fall and sampling in Hebb and Minamkeak lakes. A qualitative risk evaluation and disease testing of fish collected from above and below Hebb Dam were conducted prior to allowing migrating species into the upper lakes. The general status and distribution of illegally introduced Smallmouth Bass (*Micropterus dolomieui*) and Chain Pickerel (*Esox niger*) were assessed using several sampling methods. No Atlantic Whitefish were captured or observed in 2013 during any of the various monitoring activities. Smallmouth Bass was present in all three lakes. The broad range in body size of captured Chain Pickerel indicates that spawning is probably occurring in Hebb and Milipsigate lakes.

RÉSUMÈ

En 2013, l'état et la répartition des populations sauvages restantes de corégones de l'Atlantique (*Coregonus huntsmani*), en voie de disparition, ont fait l'objet d'une surveillance dans trois petits lacs reliés entre eux, les lacs Hebb, Milipsigate et Minamkeak, situés en amont du bassin versant de la Petite Rivière, dans le comté de Lunenburg, dans le sud-ouest de la Nouvelle-Écosse. Les activités de surveillance ont consisté en un échantillonnage quotidien des poissons migrant par la passe à poissons du barrage du lac Hebb au printemps et à l'automne et un échantillonnage des poissons dans les lacs Hebb et Minamkeak. Une évaluation qualitative des risques et un dépistage des maladies des poissons capturés en amont et en aval du barrage du lac Hebb ont été effectués avant de permettre la migration de l'espèce dans les lacs situés en amont. L'état et la répartition des populations d'achigans à petite bouche (*Micropterus dolomieui*) et de brochets maillés (*Esox niger*), introduites illégalement, ont été évalués en utilisant plusieurs méthodes d'échantillonnage. Aucun corégone de l'Atlantique n'a été capturé ni observé en 2013 durant l'une ou l'autre des différentes activités de surveillance. L'achigan à petite bouche était présent dans les trois lacs. La vaste gamme des tailles et la répartition des brochets maillés capturés indiquent que les populations reproductrices se trouvent dans les lacs Hebb et Milipsigate.

PREFACE

Atlantic Whitefish (*Coregonus huntsmani*) is an endemic Canadian species known historically only in the Tusket and Petite Riviere watersheds in southwestern Nova Scotia. The anadromous population that existed in the Tusket River is believed to be extirpated (DFO 2009). Atlantic whitefish presently exist in the wild as a landlocked population within three small (16 km^2) interconnected and semi-natural lakes, Hebb, Milipsigate and Minamkeak (Figure 1) in the upper Petite Rivière watershed in Lunenburg County, in southwestern Nova Scotia (DFO 2006; 2009). Dams constructed during the 19th and 20th centuries along the main stem of the Petite Rivière and between the three lakes either block or impede fish passage (Figure 1). Upstream migration of fishes from the Petite Rivière into the upper watershed is blocked by a dam across the outlet of Hebb Lake (Figure 2). Until September 2012 and the commissioning of a fish passage facility, Atlantic Whitefish falling over the dam from Hebb Lake were unable to return to the lake where reproduction occurs.

In 1984, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated Atlantic Whitefish as endangered on the bases of a pronounced decline in population numbers and the restriction of the population to the Tusket and Petite river drainages. Their endangered designation was re-examined and confirmed in 2000 and 2010 (COSEWIC 2010). Atlantic Whitefish was listed as an endangered species under Schedule 1 of Canada's *Species at Risk Act* (SARA) following proclamation of the Act in June 2003. The Act provides legal protection for the species by prohibiting the killing or harming of individual fish and requiring the development of a recovery strategy and action plan to protect and recover the species. A recovery strategy for Atlantic Whitefish was developed in 2006 through the cooperative effort of the Atlantic Whitefish Conservation and Recovery Team (AWCRT), comprised of experts and representatives from multiple levels of government, environmental non-government organizations, universities and industry groups. The recovery strategy goal is to achieve stability in the current population of Atlantic Whitefish in Nova Scotia by protecting and conserving the species and its habitat, re-establishing a sea-going component and expanding the species distribution beyond its current range (DFO 2006). Actions considered essential to their survival and recovery include mitigating threats, increasing the range and number of self-sustaining Atlantic Whitefish populations, restoring anadromy, and increasing understanding of the species and its habitat in the Petite Rivière (DFO 2006).

Various research activities in support of the recovery goal and action plan have been conducted annually since 2000 in the upper lakes by Fisheries and Oceans Canada (DFO), acting alone or in collaboration with the Bluenose Coastal Action Foundation (BCAF). Activities include monitoring the abundance and distribution of Atlantic Whitefish and other native as well as non-native (invasive) fish populations in the Petite Rivière watershed and evaluating the impact of restoring access for migrating fish into the upper lakes. The Canadian Manuscript Report Series will be used to report on annual sampling activities.

INTRODUCTION

In 2013, activities were conducted by DFO and BCAF in support of monitoring the abundance and distribution of Atlantic Whitefish and other fish species in the Petite Rivière watershed. The activities included daily sampling of all fish migrating through the recently constructed and commissioned fish passage facility at Hebb Dam during spring and fall 2013, and sampling Hebb and Minamkeak lakes using trap nets, seines, angling and boat electrofishing during the summer and fall.

Prior to opening the Hebb Dam fish passage facility in September 2012, an Interim Monitoring Plan (IMP, Appendix 1) was developed to ensure a phased and precautionary approach to allowing migrating fishes into the upper lakes. As part of the IMP, DFO prepared a qualitative evaluation of the risks (Appendix 1) associated with allowing all potentially migrating fish species access to the lakes above Hebb Dam, including the risks to the resident Atlantic Whitefish population. The evaluation was based on the framework established by the National Code on the *Introductions and Transfer of Aquatic Organisms* (http://www.dfo-mpo.gc.ca/science/enviro/ais-eae/code-eng.htm). In accordance with the approach recommended by the IMP, DFO also evaluated the risk of disease transmission by migrating fish to species inhabiting the lakes above the dam. Brook Trout (*Salvelinus fontinalis*) were collected from locations both above and below Hebb Dam in early spring 2013, and tested for fish diseases. Similar collections of Brook Trout for fish disease testing were conducted in the spring of 2012.

The abundance and distribution of two illegally introduced non-native fish species in the watershed: Smallmouth Bass (*Micropterus dolomieui*) and Chain Pickerel (*Esox niger*), were monitored. Both species are expected to impact Atlantic Whitefish directly through predation and competition and indirectly by changing the fish communities present in the lakes (MacRae and Jackson 2001; Bradford et al. 2004; Chaput and Caissie 2010; Mitchell et al. 2013). Smallmouth Bass was first reported in the lakes above Hebb Dam in 2000 (Bradford et al. 2004) and its distribution and spawning success in the lakes have been monitored by BCAF in collaboration with the Nova Scotia Department of Fisheries and Aquaculture (BCAF 2011, 2012). Chain Pickerel was first reported in the watershed in May 2013 by a recreational angler fishing in Little Lake, a small lake which feeds into the northern end of Hebb Lake (Figure 3). Their presence in Little Lake was confirmed when a 25.5 cm fork length (FL) individual was angled on May 17th, 2013 (Figure 3). Fyke nets, eel pots, minnow traps, angling and electrofishing were subsequently conducted from late spring to autumn to assess the size range and the extent of Chain Pickerel distribution in the lakes. All Chain Pickerel and Smallmouth Bass captured were retained, measured and their stomachs were sampled for a separate diet study.

PART 1. MONITORING ACTIVITIES IN UPPER PETITE RIVIERE WATERSHED

HEBB DAM

The primary objective for constructing the fish passage facility at Hebb Lake was to allow any Atlantic whitefish that make their way over the dam to return to the upper lakes which are the only locations where reproduction is known to occur. The facility secondarily supports the Recovery Strategy (DFO 2006, 2014) and associated Action Plan (DFO 2014) for Atlantic Whitefish by contributing to the conditions necessary for anadromy to develop among the Atlantic Whitefish population. The facility was constructed by the Public Service Commission of Bridgewater and opened for the first time in the fall of 2012.

The IMP was developed by DFO in collaboration with a working group of the AWCRT in preparation for the opening of the fish passage facility (fish way). The IMP provides species-specific operational protocols related to fish passage into Hebb Lake by native and non-native fish species. The long term goal is to allow free passage to all wild native fish species with particular monitoring protocols and restrictions or removals for some species. A fish assessment facility (i.e., fish trap, Figure 4) was installed in one of the lower pools of the fish way by DFO with the following objectives:

- Demonstrate that the facility is capable of facilitating upstream passage of Atlantic Whitefish as well as other fish species into Hebb Lake.
- Contribute to the understanding of a number of biological questions (such as habitat use, population size, movement and migration timing, biological characteristics and condition) related to Atlantic Whitefish and other fish species.
- Assess the feasibility of using the facility to control the numbers of fish per species entering the lake and/or prohibit entry of unwanted (e.g., invasive) fish species, if and when those controls may be required.
- Provide experience and information for fish passage needs around man-made barriers, or impediments, to fish passage issues both elsewhere on the Petite Rivière and elsewhere within the historical range of Atlantic Whitefish.

The fish passage facility was monitored daily by BCAF from September to December 2012. Water levels were not monitored, so the influence of daily flows on fish through the fish way could not be evaluated. All species were enumerated and measured. As directed in the IMP, only wild origin Atlantic Whitefish, Atlantic Salmon, Brook Trout and American Eel were released upstream. The total number of fish observed was 19 Atlantic Whitefish, 4 Atlantic Salmon, 13 Brook Trout, 2 American Eel, 3 Smallmouth Bass, 36 White Sucker and 2 White Perch.

Spring 2013 Monitoring (May-June)

The fish passage facility was opened and monitored daily for three days from April 16-19 as a method for catching Brook Trout for fish health testing. It was opened again and monitored daily from May 10- June 28 (58 days). A temperature data logging device installed in the fish way recorded water temperature every 30 minutes from April 1 to June 30. The fish trap was checked daily by BCAF staff, usually in the morning. All fish intercepted in the trap were identified, counted, sampled and handled as per the IMP protocols. These were the same as in 2012 except that the release protocols defined in the IMP were revised for the spring 2013 opening of the fish passage facility to allow up to 30,000 gaspereau (Alewife (*Alosa pseudoharengus*), Blueback Herring (*Alosa aestivalis*)) to enter into Hebb Lake through the fish way (Appendix 1).

Daily average water temperatures ranged from 9 °C -11°C during the four days that the fish way was open in April (Figure 5). Daily temperatures in May averaged 15.8°C; the lowest temperature was recorded on May 3 (12.3 °C) and the highest temperature (18.2 °C) occurred five days later on May 8 (Figure 5). Temperatures declined after May 8 and remained cooler until the third week of May with a low of 13.4 °C on May 22. Water temperatures rose rapidly at the end of May from 14.8 °C on May 28 to 21.2 °C on June 1. A similar midmonth decline in temperatures occurred in June with a high of 16.2 °C on June 14 and a high of 24.8 °C on June 25. Daily temperatures in June averaged 20.1 °C. Daily minimum and maximum temperatures differed by as much as 2 °C in April and 3 °C in May and June.

Only two fish, both White Sucker (*Catastomus commersonii)*, were caught during the three days sampled in April 2013 (Figure 6). Eight species were intercepted in the fishway trap during the May-June monitoring period; the most abundant and frequently occurring was gaspereau (n = 2,120) followed by White Sucker (n= 174) and Smallmouth Bass (n= 18) (Table 1). There were single occurrences of American Shad (*Alosa sapidissima*), Sea Lamprey (*Petromyzon marinus*) and Brook Trout. No Atlantic Whitefish were intercepted in the fish trap.

The majority of the daily catch in May was White Sucker (Figure 6). Although suckers were regularly caught until the fish way was closed at the end of June, most of the fish entering the fish way from May 28 to June 12 were gaspereau (Figure 6). Smallmouth Bass was the only other regularly occurring species at the fish way (Figure 7).

The appearance of the gaspereau was coincident with the rise in water temperatures at the end of May (Figure 8). The largest catches of gaspereau were on May 31 and June 1 (n=321). From May 28-June 28, when the most of the run was gaspereau, more fish migrated through the fish way on sunny days (16 days, 1365 fish) than overcast days (16 days, 551 fish).

Detailed observations were not collected that could be used to differentiate the two species of gaspereau, nor were lengths taken. Five gaspereau that died impinged on the upper side of the trap were examined and found to be Alewife.

A broad size range of White Suckers were caught in the fish way, ranging from 10 to 40 cm FL with a median of 18 cm FL (Figure 9). Smallmouth Bass ranged from 18-28 cm FL with a median FL of 22.5 cm (Figure 10).

Fall 2013 Monitoring (October - November)

Monitoring fish migration at the Hebb Dam fish way was resumed by BCAF staff on October 2, 2013 and continued daily for 59 days until November 29 using the same IMP operational protocols as in the spring of 2013.

Daily average water temperature showed a steady decline from about 16 °C in October to less than 2 °C on December 11 and then remained at about 1 °C until the end of December (Figure 11). The average difference between daily minimum and maximum for all days was less than 1 °C.

A total of 16 fish comprising three species were caught in the fish trap in the fall (Table 2). White Sucker was the most frequently caught species (Figure 12). A single

Smallmouth Bass was caught on October 18th. The capture of a single Chain Pickerel (22.8 cm FL) on November 3, 2013 in the trap was a first record for the fish way (Table 2). A second individual (25.5 cm FL) was found impinged on the upstream side of the trap on November 5, 2013. A single Brown Bullhead (*Ictalurus nebulosus*) was found on the upstream side on the same day. No Atlantic Whitefish were observed during fish way monitoring in 2013. No fish of any species were observed in the trap after November 16 (Figure 12).

The size range of White Suckers was narrower (length range 11.6 - 20.0 cm FL) (Figure 13) than those caught during spring (10–40 cm FL).

Comparisons with monitoring results from Fall 2012

Both species diversity and total numbers were lower in the fall of 2013 than observed during the fish way monitoring activities conducted in the fall of 2012. A total of 79 individuals within six species were caught in fall 2012 compared to 19 individuals among five species in fall 2013. Species caught in 2012 but not 2103 were Atlantic Whitefish and Atlantic Salmon (*Salmo salar*). A single Brook Trout was observed in fall 2013 compared to 13 individuals in 2012.

The total absence of Atlantic Whitefish in 2013 was a disappointment, given that 19 individuals were sampled at the fish way in 2012. A single individual arrived at the fish way on October 2, 2012, followed by a group of 18 fish 13 days later. Four Atlantic Salmon were caught on November 19th, 2012 compared to none during fall monitoring in 2013.

The capture of Chain Pickerel both inside and above the fish trap indicate that Chain Pickerel is present both below the dam in the Petite Rivière and above the dam in Hebb Lake.

HEBB LAKE (BELOW MILIPSIGATE DAM)

Floating Trap Net (May - June)

Surveys prior to 2010 have shown that the outflow below Milipsigate Dam is an area where Atlantic Whitefish congregated during May. A floating frame trap net 6 m long (24 feet) by 3 m wide (10 foot) by 3 m deep (10 feet) and composed of netting with a stretched mesh size of 2.54 cm was set in Hebb Lake in the outflow below Milipsigate Dam from May 30 – June 13 (Figure 14), the same location in which the same trap net was deployed from May 6 to May 14, 2012. The mouth of the trap net was on the downstream side. Two leaders, each 30 m long in length, were set in a V-shape extending to the banks of the lake (Figure 14). The first day (May 30th) the trap fished for 21.5 hours. Effort among the following fishing days varied in order to manage the volume of the catch (all species) and reduce likelihood of Atlantic Whitefish mortality (Table 3).

Six species were captured (Table 4). Species with the highest catch rates were White Perch (*Morone americana*) (18 fish per hour) followed by White Sucker (8 fish per hour), Gaspereau (6 fish per hour) and Smallmouth Bass (1 fish per hour) (Table 4). The other two species caught were Creek Chub (*Semotiilus atromaculatus*, n=1) and American

Eel (*Anguilla rostrata*, n=2). Most of the fish were caught on the first day (May 30) with catches declining 80% or more on subsequent sampling dates (Figure 15).

The 24 Smallmouth Bass captured displayed a broad length range (18-49 cm FL) with multiple modes, indicating the presence of several year classes (Figure 16).

Species composition in 2013 was the same as that observed in 2012 with the exception of the appearance of gaspereau due to their first opportunity to enter Hebb Lake through the fish way operating in spring 2013. These appeared at the fish way for the first time on May 10 and were caught on the first day of fishing the trap net (May 30).

No Atlantic Whitefish were captured by trapnet below Milipsigate Dam in 2013. In 2012, no Atlantic Whitefish were captured during daily monitoring from May 6 to May 14, 2012. Trapnets installed in the same location in earlier years caught 8 fish in 2000, 5 fish in 2001, and 16 fish in 2003 (n= 29 fish in total) (DFO 2009).

Seining (October 3rd)

A single attempt was made to seine the pool in the outflow from Milipsigate Dam, on the morning of October 3, 2013 in the same location as the trapnet installed from May 30-June 13 (Figure 14). The seine was equipped with a lead line along the bottom edge and its dimensions were 61 m long (200 feet) by 4.6 m deep (15 feet) with a stretched mesh size of 2.5 cm mesh (1 inch). The seine was deployed from the right bank (facing downstream) immediately below Milipsigate Dam, using a boat to pay out the seine and bring it over to the left bank downstream of the dam (Figure 17). The total time to encircle the area and purse the seine was 30 minutes. Surface water temperature was 16.8 °C at the time of sampling.

Four White Suckers were observed on the inside of the seine during deployment but no fish of any species were captured. We suspect that the suckers escaped through the crevices between the large rocks that form the stream bottom. Visibility was very good and apart from the observed suckers, nothing occurred to suggest that the lack of fish was due to problems with the method.

Previous seining events in the same location yielded 26 Atlantic Whitefish in May 2000, 12 Atlantic Whitefish in May 2006 and 29 Atlantic Whitefish in June 2007 (DFO 2009). There have also been observations of Atlantic Whitefish at this site by DFO and BCAF staff on shore on other occasions (DFO 2009; Bradford et al. 2010). The last recorded visual observation of Atlantic Whitefish (total=2) at this location was on May 23, 2012 (BCAF 2012). No Atlantic Whitefish were observed by either DFO or BCAF staff at this particular location at any time during 2013.

MINAMKEAK LAKE

Floating Trap Net (September-October)

In 2013, sampling Atlantic Whitefish in Minamkeak Lake using trap nets was attempted for the first time since 2009. The two trap nets set in Minamkeak Lake (Figure 18) had the same dimensions as the trap used in the outflow from Milipsigate Dam, except for depth. The first trap net with a depth of 3 m (10 feet) was deployed on September 30 and checked for the first time on October 2. A second trap net with a 4.6 m (15 feet) depth was set on October 7. Both nets were set on the Monday of each week and checked each weekday to the extent possible, except when high winds prevented access to the traps. Fishing duration (time between when the net was opened and closed) averaged 24 hours and the traps were checked on 17 occasions over the 31 day fishing period (Table 5). Both traps were removed on November 30. The total number of hours fished was 429 hours for the 3 m trap and 338 hours for the 4.6 m trap (Table 5).

No Atlantic Whitefish or Chain Pickerel were caught in the trapnets installed in Minamkeak Lake. The four species caught collectively in the two traps were White Perch (n=300), Brown Bullhead (n=3), White Sucker (n=1) and American Eel (n=1) (Table 6). Overall catch rates were low. Only White Perch occurred as multiple individuals and on more than two sampling dates (Table 6). White Perch ranged in size from 13 -18 cm FL (Figure 19). The 4.6 m deep trap was the more effective of the two traps, capturing 83% of the total combined catch from both traps (Table 6).

There has been little sampling of Atlantic Whitefish previously in Minamkeak Lake. Two trapnets installed in the same location in 2009 and monitored daily from October 1 to October 30 caught one Atlantic Whitefish on October 2nd and another on October 9th (DFO, unpubl. data). Nineteen were caught in 2004 using gillnets (DFO 2009). The absence of Atlantic Whitefish in 2013 sampling may be due to several reasons such as a poor choice of location for the trapnets, low susceptibility to capture in trapnets as well as low numbers of Atlantic Whitefish present in the lake.

PART 2. FISH HEALTH SCREENING: RECORD OF COLLECTIONS AND RESULTS

In preparation for opening the fish way in spring 2013, Brook Trout were collected from locations both above and below Hebb Dam to serve as resident species for screening of fish pathogens of concern. All collections were made using backpack fishing gear. Fish were sealed individually in plastic bags labelled to show day and location of capture, packed in a cooler filled with ice and sent the same day to the Fish Health Unit, DFO Gulf Region at Moncton, New Brunswick to be examined for pathogens screened under the Regional Fish Health Protection Guidelines (RHFP). Those pathogens are causative agents of Furunculosis and Enteric Redmouth Diseases, and Bacterial Kidney Disease (BKD) (i.e. lesions caused by *Renibacterium salmoninarum*), and Infectious salmon anaemia (ISAV). Sampling Brook Trout was considered suitable for screening for disease risks that might be associated with White Sucker, Alewife or Blueback Herring (Appendix 1), according to the Regional Fish Health office (Appendix 1). A similar collection of Brook Trout was conducted in 2012 to test for the same diseases, as well as infectious pancreatic necrosis (IPN). In 2012, no fish pathogens of concern were found except IPN which was found in the trout collected downstream of the dam. As this virus is found throughout trout populations in the Maritime Provinces it was not considered a disease agent of concern (Appendix 1).

A total of 27 Brook Trout were collected from six locations (on two occasions in two of the locations) below Hebb Dam from April 17 to April 23 (Table 7, Figure 20). Thirty Brook Trout were collected from four sites upstream of Hebb Dam on April 22, 2013 (Table 7, Figure 20). All fish were sampled within 48 hours at the Fish Health Unit.

No fish pathogens of concern were noted by the Fish Health Unit (Appendix 3). These results indicate that the communicable fish pathogens and diseases are neither in the lake fish populations or likely to be introduced by species migrating into the lakes through the fish way.

PART 3. SURVEY OF INVASIVE SPECIES IN PETITE RIVIÉRE WATERSHED

EXPLORATORY ANGLING SURVEYS (*April-October*)

Angling surveys directed at Smallmouth Bass and Chain Pickerel were conducted in from April 25 to October 21 in Hebb, Milipsigate and Minamkeak lakes and other lakes connected to them by tributaries (Figure 21). The objective was to assess the extent of distribution and relative abundance of the two species throughout the three lakes. Two to three anglers fished a range of habitats including rocky drops, vegetated areas and areas with flowing water from shore or from a 14 foot aluminum boat equipped with a four stroke motor, using spinning rods and artificial lures (mainly artificial worms, also spinners, rapalas and shad darts). Fishing effort was concentrated on the outflow below Milipsigate Dam where a similar angling survey conducted by BCAF staff in 2012 produced high catch rates of Smallmouth Bass (BCAF 2012). The 2012 surveys also had high catch rates in Milipsigate and Minamkeak lakes and a low catch rate in Hebb Lake itself (BCAF 2012).

Smallmouth Bass

A total of 516 Smallmouth Bass were captured during 101.5 hours of angling at ten locations over the course of the exploratory surveys in 2013 (Table 8). Highest averaged catch rates occurred just below Hebb Dam where 32 fish were caught in 1.3 hours of fishing over three days in August. Averaged catch rates were also high in Andrew Lake (12.3 fish per hour) located above Milipsigate Lake and draining into it via Birch Brook, in the Petite Rivière immediately below Hebb Dam (6.7 fish per hour) and in Hebb Lake below the outflow from Milipsigate Dam (7.4 fish per hour).

A comparison of monthly catch rates at the outflow below Milipsigate Dam indicates that Smallmouth Bass were more susceptible to angling in May through August than in early spring or in the fall (Table 9). The highest catch rate in a single event occurred on May 13 when 37 fish were caught in 30 minutes.

The overall size range of Smallmouth Bass caught by angling was 12.2-46.0 cm FL. The capture of multiple size classes in all lakes (Table 8) and the length frequency distribution (Figure 22) indicate that Smallmouth Bass of several year classes are present throughout the watershed, as has been the indication from sampling conducted during 2012 (BCAF 2012).

Chain Pickerel

A total of 23 Chain Pickerel were removed by angling from Hebb (n=19), Milipsigate (n= 2, Garber (n= 1) and Little lakes (n= 1) (Figure 23, Table 10). No Chain Pickerel were captured in Minamkeak Lake or the Petite Rivière below Hebb Dam by angling. The overall length range was 22.7-44.1 cm FL indicative of the presence of multiple size classes in the Hebb and Milipsigate lakes (Figure 23).

VARIOUS FIXED GEAR (April-June)

A fyke net was deployed at the Weagle Dam outlet of Hebb Lake from April 10 2013 until May 9 2013 (Figure 24, Table 10) in order to monitor any downstream migration of Atlantic Whitefish. Following the discovery of Chain Pickerel in Little Lake on May 17, 2013, sampling activities were initially aimed at assessing the extent of the distribution of Chain Pickerel in Hebb Lake and preventing migration between lakes. A fyke net was set in the Milipsigate Lake overflow channel (Figure 25) from June 17-June 21 to completely blocked the channel and prevent any upstream migration of Chain Pickerel into Milipsigate Lake. The nets were checked daily.

Seventeen eel pots and six minnow traps were deployed in Hebb Lake between June 10th and June 19th 2013. The traps were placed in three locations: the Pinch gut, the outflow below Milipsigate Dam and a cove in Hebb Lake close to the outflow (Figure 24, Table 11). All gear was placed in shallow, grassy areas which appeared to have the habitat characteristics preferred by Chain Pickerel, and monitored and baited daily with pieces of Smallmouth Bass.

Four Chain Pickerel were captured in total, two in the fyke net placed in the Milipsigate Lake overflow channel (n=2) and one each in the minnow traps (n=2) placed in Pinch Gut and the cove in Hebb Lake (Tables 10 and 11). The capture of a gaspereau in the fyke net set in the overflow channel (Table 11) indicates that the channel provides accessible, upstream passage between Hebb and Milipsigate lakes for at least part of the year. A 4.5 cm FL Chain Pickerel was caught in one of the eel pots set in Hebb Lake Cove (Table 10). A fish this small is a young of the year (< 1 year old) and evidence that Chain Pickerel are reproducing in Hebb Lake.

BOAT ELECTROFISHING (Mid-July)

Sampling with a boat-mounted electrofisher has not been previously attempted in the Petite Riviere watershed. Exploratory sampling of Milipsigate and Minamkeak lakes was conducted from July 15-18 to assess the potential for boat-electrofishing as a method for the collection and removal of invasive species.

The objectives were to document the presence, distribution and relative abundance of Chain Pickerel and Smallmouth Bass in each lake and collect data on body-size distribution and catch rates for all species sampled during electrofishing. Each station constituted the area of a small cove. Sampling protocol consisted of a single pass at a constant boat speed. Shock time at a given station was based on the amount of time it took to sample the entire cove.

Milipsigate Lake Sampling (July 15-16)

Sampling sites in Milipsigate Lake were selected based on whether they had one or more of the following attributes: 1. Locations where the passage of fish from Hebb to Milipsigate lakes was possible during seasonal high water flow; 2. Presence of emergent vegetation which is generally considered to be preferred habitat for Chain

Pickerel; and 3. Sites at which Chain Pickerel had been angled; and 4. Mouths of tributaries where Atlantic Whitefish have been observed to aggregate. Ten stations were sampled in Milipsigate Lake over July 15-16 (Table 12, Figure 26, Appendix 3) The average shock time was 716 seconds (Table 12).

A total of 378 fish was captured in Milipsigate Lake, including 32 Chain Pickerel and 170 Smallmouth Bass (Tables 12 and 13). Catch rates of Smallmouth Bass are underestimated at some stations as not all Smallmouth Bass observed during shocking were dip netted and sampled. The sites at which this occurred were not recorded. Smallmouth Bass were captured at every site with catch rates ranging from 51–154 fish per hour. Catch rates of Chain Pickerel ranged from 6 to 76 fish per hour at the five stations (stations #3, 4, 6, 7 and 10) positive for Chain Pickerel. A broad size range representing both adults and juveniles of each species was captured (Figures 27 and 28). Other species captured included White Perch, White Sucker and Yellow Perch (*Perca flavescens*) (Table 13).

Chain Pickerel were consistently located in shallow water (1-1.2 m) with dense vegetation (Table 12), a kind of habitat that is widely available in Milipsigate Lake. An absence of Atlantic Whitefish in electrofishing samples was consistent with their preference for the cooler waters located in the deeper, more centrally located region of the lake (Cook et al. 2013).

Minamkeak Lake (July 17-18)

Minamkeak Lake differs from Milipsigate Lake; there are generally steeper shoreline gradients, a greater volume of deep water, a larger surface area and a lower abundance of emergent vegetation. The twelve sites sampled in Minamkeak Lake (Figure 29) were selected based on whether they had the kinds of habitat most similar to stations at which Chain Pickerel occurred in Milipsigate Lake, i.e., the mouths of brooks and areas with emergent vegetation.

A total of 330 fish were captured, including 118 Smallmouth Bass, (Table 14 and 15, Appendix 3). No Chain Pickerel or Atlantic Whitefish were captured. Minamkeak Lake had much less of the kind of habitat in which Chain Pickerel were found in Milipsigate Lake, with areas of emergent vegetation only occurring within coves located at the north and west ends of the lake. Catch rates of Smallmouth Bass as high as 210 fish per hour were estimated which is higher than at any of the stations sampled in Milipsigate Lake. Sizes of this species ranged from 9 to 28 cm FL, representing both juveniles and adults (Figure 30). Species composition in Minamkeak Lake was more diverse than Milipsigate Lake with catches including a variety of small freshwater fishes such as Banded Killifish (*Fundulus diaphanus diaphanus*), Common Shiner (*Luxilus cornutus*) and Brown Bullhead.

These results indicate that Chain Pickerel may not as yet have ascended the system into Minamkeak Lake; however Smallmouth Bass are abundant in this lake.

SIZE COMPOSITION OF INVASIVE SPECIES

Smallmouth Bass

A comparison of the length frequency of all Smallmouth Bass caught by the two gears at all locations indicates that both caught a broad size range: angling (n=516) caught fish 13-46 cm FL and boat electrofishing (n=288) caught 8-41 cm FL (Figure 31). The modes were different with angling tending to catch larger fish (>26 cm FL) than the electrofishing boat, suggesting that small (<16 cm FL) individuals may be more susceptible to capture via boat electrofishing (Figure 31). The difference in susceptibility to the gear employed is more apparent when comparing the length frequencies of Smallmouth Bass caught in Milipsigate Lake by the two methods; angling did not catch the smaller bodied (<20 cm FL) observed in electrofishing catches *(*Figure 32).

The absence of larger fish in boat electrofishing catches may be due to their unavailability during the summer months in the regions of the lake electrofished rather than gear avoidance. Angling occurred throughout the months of May to September, compared to the two days sampled by boat electrofisher in July in each of Milipsigate and Minamkeak lakes, and included fishing on spawning redds guarded by adults males. The length range of Smallmouth Bass caught by angling in Milipsigate Lake in July and August (n= 11, 18.2-22.2 cm FL) was narrower and the fish generally smaller than those angled in June and September (n = 45, 16.5-30.8 cm FL). Both smaller and larger fish were captured by the electrofishing boat (length range 7.5-40.4 cm FL). It would be of interest to conduct some electrofishing trials in the spring to see if the larger bodied individuals capable of predating Atlantic Whitefish would be more available to capture by electrofishing boat. The electrofishing boat is always more effective in catching smaller bodied individuals. A multiyear boat electrofishing program in Miramichi Lake, New Brunswick also captured a high proportion of small-bodied (young of the year) Smallmouth Bass (DFO 2013) and caught few large, mature individuals.

Chain Pickerel

Small bodied (<23 cm FL) Chain Pickerel were only sampled by boat electrofisher while most fish caught by angling were larger than 25 cm FL (Figure 33). Sample sizes of Chain Pickerel captured by boat electrofishing (n=32) and angling (n=23) are too small to relate these to size-related differences in susceptibility to gear type, but some inferences can be made. Chain Pickerel in Milipsigate Lake appear less susceptible to angling than Smallmouth Bass; 21.3 hours of angling effort only captured two Chain Pickerel (June 18, 27.2 cm FL; September 16, 22.5 cm FL) compared to 74 Smallmouth Bass.

SUMMARY

No Atlantic Whitefish were either captured or observed in 2013 by any sampling method during any of the various months of sampling or in any of the locations sampled. The absence of Atlantic Whitefish from the outflow below Milipsigate Dam is a concern considering that this is a location at which Atlantic Whitefish have been sampled on several occasions in previous years. The lack of Atlantic Whitefish in the Hebb Dam fish way in 2013 was unexpected because they were sampled in the fish way in fall 2012.

We only have two years of data as the fish way was first opened in fall 2012. Resuming monitoring in fall 2014 would help identify any trend.

The risk of disease transmission to fish species residing in the upper lakes by migrating species is low based on the absence of fish diseases in the Brook Trout tested.

Gaspereau were permitted into Hebb Lake through the fish passage facility for the first time in May 2013. All were allowed to ascend as the total number sampled was only 7% of the maximum capacity of 30,000 gaspereau set in the IMP. The occurrence of gaspereau in the trapnet set in the outflow below the Milipsigate Dam indicates that some of the migrating gaspereau had dispersed throughout Hebb Lake by the end of May. The capture of a gaspereau in the fyke net set in the Milipsigate overflow channel indicates that gaspereau may have migrated from Hebb Lake into Milipsigate Lake during the spring migration.

Chain Pickerel were collected from Hebb and Milipsigate lakes, but were not found in Minamkeak Lake. Sampling protocols and intensity using angling and a boat electrofisher were sufficiently similar in Milipsigate and Minamkeak lakes to indicate that Chain Pickerel have not become established in Minamkeak Lake. Their presence in numbers below the limits of detection cannot however be excluded.

Chain Pickerel were found in Milipsigate Lake at sites with shallow water and dense vegetation. Minamkeak Lake had comparatively less of this habitat.

Boat electrofishing has the potential to be an efficient method of controlling Smallmouth Bass and Chain Pickerel abundance and production. However, removal of large-bodied individuals capable of predating on juvenile and adult Atlantic Whitefish may require multiple kinds of gear, or altering boat electrofishing protocols, for example, sampling earlier in the year when Smallmouth Bass are spawning.

Species composition from boat electrofishing indicates that Smallmouth Bass is probably the most abundant fish species present within the littoral zones of both Milipsigate and Minamkeak Lakes during the summer months.

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TABLES

Table 1. Total numbers, frequency of occurrence and first and last dates caught of species captured during daily monitoring at the Hebb Dam fish way from April 16-19 and May 10-June 28, 2013.

Species	Total Catch (numbers)	Number Occurrences	First Day Observed	Last Day Observed
Gaspereau	2,120	48	May 10	June 27
White Sucker	174	31	April 16	June 26
Smallmouth Bass	18	15	May 15	June 28
American Eel	3	3	May 31	June 7
Creek Chub	5	5	May 12	June 14
Brook Trout	1	1	June 27	June 27
Sea Lamprey	1	1	June 3	June 3
American Shad	1	1	June 2	June 2

Table 2. Total numbers, frequency of occurrence and first and last dates caught of species captured during daily monitoring at the Hebb Dam fish way from October 2-November 29, 2013.

Species	Total Catch (numbers)	Number Occurrences	First Day Observed	Last Day Observed
White Sucker	14	6	October 3	November 6
Smallmouth Bass	1	1	October 18	October 18
Brook Trout	1	1	November 16	November 16
Brown Bullhead	1	1	October 5	October 5
Chain Pickerel	2	2	November 3	November 5

Table 3. Operation data for the floating trap net set below Milipsigate Dam from May 30-June 13, 2013 (duration – hours elapsed between opening and closing the entrance to the trap).

Date	Time Fished (hr: min)	Duration (hrs)	Water Temp (°C)	Catch (numbers)	Mortalities
May 30	10:30	21.5	16.0	573	64 White Perch
May 30	13:00	1.5	17.5	116	15 White Perch
May 31	13:00	3.0	19.9	126	12 White Perch
June 10	14:00	4.5	18.7	5	-
June 13	15:00	5.5	17.2	27	6 gaspereau

Table 4. Fish caught in the floating trap net set below Milipsigate Dam from May 30-June 13, 2013 (Total fishing time = 36 hours; Fish per hour – average catch per hour sampling; Standard Deviation (SD) shown in brackets).

Species	Total Catch (numbers)	Fish per Hour (SD)	Occurrences	First Day Observed	Last Day Observed
Gaspereau	95	6 (6.8)	4	May 30	June 13
White Sucker	353	8 (6.7)	4	May 30	June 13
Smallmouth Bass	24	1 (2.0)	2	May 30	May 31
American Eel	2	0.1 (0.3)	1	May 30	May 30
Creek Chub	1		1	May 30	May 30
White Perch	372	16 (20.5)	2	May 30	May 31

Table 5. Operational data for trap nets set in Minamkeak Lake from September 30-October 30, 2013. (Duration – hours elapsed between opening and closing the entrance to the trap).

Date	Time Fished (hr:min)	Duration (hr)	Water Temperature °C	Catch (numbers)	Comments
02-Oct	10:00	44.5	16.1	1	First (3m deep) trap set
03-Oct	12:00	26	16.8	0	
04-Oct	09:15	21.3	16.2	44	
08-Oct	12:30	26.5	16.1	12	Added second (4.6 m deep) trap
09-Oct	09:15	20.8	15.8	23	21 fish caught in 4.6 m trap
10-Oct	09:30	24.3	15.6	66	64 fish caught in 4.6 m trap
11-Oct	09:30	24	15.5	28	26 fish caught in 4.6 m trap
16-Oct	09:30	24	14.5	127	All fish caught in 4.6 m trap
17-Oct	10:30	25	15	0	
18-Oct	11:30	25	14.7	1	Fish caught in 3 m trap
22-Oct	09:00	24	13.7	1	Fish caught in 3 m trap
23-Oct	09:00	24	13.7	0	
24-Oct	09:00	24	13.8	1	Fish caught in 4.6 m trap
25-Oct	09:00	24	12.8	0	
29-Oct	09:00	24	11.1	0	
30-Oct	09:00	24	10.9	0	
31-Oct	09:00	24	10.5	0	

Table 6. Species composition of catch from two floating traps fished in Minamkeak Lake from September 30-October 30, 2013 (total fishing time 3 m trap = 430 hours; 4.6 m trap = 338 hours; Fish per hour – average catch per day trap fished; SD – standard deviation shown in brackets;.

	3 m deep trap		4.6 m deep trap				
Species	Catch (numbers)	(Fish per Hour (SD)	Catch (numbers)	Fish per Hour (SD)	Occurrences	First Day Caught	Last Day Caught
American Eel	0	-	1	-	1	Oct 11	Oct 11
Brown Bullhead	1	-	2	-	3	Oct 2	Oct 24
White Perch	49	4 (13.2)	251	23 (40.0)	8	Oct 4	Oct 22
White Sucker	0	-	1	-	1	Oct 11	Oct 11

Table 7. Capture dates, locations, numbers and size range of Brook Trout collected by backpack electrofishing from above and below Hebb Dam for fish health screening in April 2013 (U/S – upstream; D/S - downstream.

			Fork Length (cm)		
Date	Number	Location	Mean	Minimum	Maximum
		Below Hebb Dam			
April 15	4	Brown Branch Brook tributary	8.6	7.3	10.3
April 16	5	Brown Branch Brook	12.4	10.9	16.7
April 16	4	Branch Lake tributary (U/S)	15.2	11.4	19.5
April 17	2	Fitch Lake	11.2	10.5	11.9
April 17	2	U/S of Publicover Lake	13.5	11.0	16.6
April 23	7	Brown Branch Brook	12.4	8.5	19.4
April 23	2	Brown's Branch tributary	9.0	8.5	9.5
April 23	1	Rotary Smolt Wheel in Petite Rivière	23.4	23.4	23.4
		Above Hebb Dam			
22-Apr	18	Wildcat Brook	14.4	8.5	20.7
22-Apr	1	Sarty Brook	16	16	16
22-Apr	3	U/S from Newcombville Lake	23.3	21.4	25.6
22-Apr	11	D/S from Newcombville Lake	17.6	11.4	31.5

Table 8. Location and catch data for angled Smallmouth Bass in the Petite Rivière watershed from April-October 2013 (Fish per hour: average daily catch rate; SD – standard deviation).

					Fork Length (cm)		
Location	**Total Effort (hrs)**	**Number of Surveys**	**Catch (numbers)**	**Fish per Hour (SD)**	**Mean**	**Minimum**	**Maximum**
Petite Rivière	0.8	1	5	6.7	15.9	14.1	17.4
Andrew Lake	3.0	1	37	12.3	23.5	15.4	33.1
Fancy Lake	3.0	1	8	2.7	25.7	14.5	35.0
Hebb Dam	1.3	3	32	22 (20.3)	20.4	14.6	27.5
Hebb Lake	9.8	5	15	1.8 (0.3)	25.2	12.2	30.9
Milipsigate Dam outflow (Hebb Lake)	56.5	36	342	7.4 (12.3)	26.9	13.5	46.0
Milipsigate Lake	21.3	13	74	3.5 (1.2)	23.5	16.5	42.1
Minamkeak Lake	6.0	2	3	0.5 (0)	29.3	17.9	42.5
Garber Lake	2.5	1	0	-	-	-	-
Little Lake	0.8	1	0	-	-	-	-
Total	104.5	64	516				

Table 9. Monthly catch rates of Smalllmouth Bass by angling in Hebb Lake below outflow from Milipsigate Dam in 2013 (Fish per hour: averaged daily catch rate; SD – standard deviation)

Month	**Total Effort (hours)**	**Total Catch (numbers)**	**Fish per Hour (SD)**
April	1.0	0	0
May	17.8	157	14.0 (21.8)
June	3.0	8	2.8 (1.04)
July	6.50	47	8.0 (5.1)
August	15.8	93	6.9 (5.7)
September	140	36	2.6 (1.5)
October	0.5	1	2.0
Total	58.6	342	

Table 10. Gear and deployment dates for catching Chain Pickerel in the Petite Rivière watershed in 2013.

					Fork Length (cm)			
Location	**First and Last Dates Sampled**	**Gear**	**Total Effort (hr)**	**Catch (numbers)**	**Mean**	**Minimum**	**Maximum**	**Other Species Caught**
Weagle Dam (Hebb Lake	April 11-May 8	Fyke net	724	0	-	-	-	10 species; listed in Table 11
Milipsigate Lake overflow channel	June 18-21	Fyke net	72	2	20.0	19.0	20.9	2 Smallmouth Bass, 1 gaspereau, 2 Brown Bullhead
Hebb Dam	November 3-5	Fish way monitoring	59 days	2	24.2	22.8	25.5	Species List in Table 2
Petite Riviere	June 13	Angling	0.8	0	-	-	-	Smallmouth Bass
Andrew Lake	August 16	Angling	3.0	0	-	-	-	Smallmouth Bass
Fancy Lake	July 3	Angling	3.0	0	-	-	-	Smallmouth Bass
Garber Lake	June 17	Angling	2.5	1	43.9	43.9	43.9	None
Hebb Lake	June 12, June17	Angling	4.0	2	14.5	22.7	26.9	Smallmouth Bass
Little Lake	May 17	Angling	0.75	1	25.5	25.5	25.5	None
Milipsigate Lake	June 18, Sept 16	Angling	2.5	2	31.4	27.2	35.5	Smallmouth Bass
Milipsigate Outflow (Hebb Lake)	Sept 4-Oct 7	Angling	37.5	17	38.4	22.7	44.1	Smallmouth Bass
Milipsigate Lake	July 15-16	Electrofishing boat	2.0[1]	32	29.9	6.0	36.0	Species listed in Appendix 4
Minamkeak Lake	July 17-18	Electrofishing boat	1.3[1]	0	-	-	-	Species listed in Appendix 4
Pinch Gut (Hebb Lake)	June 12-13	Eel pot	48.0	1	32.1	32.1	32.1	4 Brown Bullhead, 3 American Eel, 1 Yellow Perch
Hebb Lake Cove (Hebb Lake)	June 19	Eel pot	24.0	1	4.5	4.5	4.5	1 American eel, 2 Yellow Perch
Milipsigate Outlet (Hebb Lake)	June 19	Eel pot	48.0	0	-	-	-	2 Brown Bullhead, 4 American Eel

1. *Effort measured as amount of time spent applying current (shocking)*

Table 11. Species composition of catch from fyke nets set in Milipsigate Lake overflow channel (June 18-21, 2013, total sampling effort = 3 days) and Petite Rivière (April 14 – May 8, 2013, total sampling effort = 30 days; NA – not sampled).

	Milipsigate Lake overflow channel				Petite Rivière (Weagle's Dam)			
		Fork Length (cm)				Fork length (cm)		
Species	**Catch (numbers)**	**Mean**	**Minimum**	**Maximum**	**Catch (numbers)**	**Mean**	**Minimum**	**Maximum**
Chain Pickerel	2	20.0	19.0	20.9	0	-	-	-
White Sucker	0	-	-	-	2	12.0	9.5	14.5
Smallmouth Bass	2	22.2	21.3	23	1	20.9	20.9	20.9
American Eel	0	-	-	-	3	47.8	35.5	55.0
Creek Chub	0	-	-	-	3	113.4	10.5	18.3
Brown Bullhead	2	NA	NA	NA	1	14.4	14.4	14.4
White Perch	0	-	-	-	51	13.9	7.5	21.2
Yellow Perch	0	-	-	-	24	8.8	5.9	12.5
Banded Killifish	0	-	-	-	1	5	5	5
Gaspereau	1	NA	NA	NA	0	-	-	-
Golden Shiner	0	-	-	-	2	10.5	9.7	11.2
Stickleback	0	-	-	-	1	6	6	6

Table 12. Station characteristics, maximum water depth, shock time and catch rate (numbers caught per hour) of Smallmouth Bass and Chain Pickerel sampled at ten sites in Milipsigate Lake by boat electrofisher on July 15-16, 2013 (SD: standard deviation).

				Catch Rate (numbers per hour)	
Station	**Estimated Percent of Station Covered by Vegetation**	**Maximum Water Depth (m)**	**Shock Time (seconds)**	**Smallmouth[1] Bass**	**Chain Pickerel**
1	0	1.5	662	76	0
2	70-80	1.2	366	89	0
3	60	1.0	435	108	17
4	60-70	1.2	1346	27	16
5	20	1.0	633	97	0
6	20	1.0	726	154	10
7	0	1.0	646	150	6
8	0	1.2	432	150	0
9	90%	3.0	922	66	0
10	80%	1.0	990	51	76
Mean Catch Rate (SD)				96.7 (44.1)	12 (23.4)

1. Minimum catch rates of Smallmouth Bass as not all bass shocked were collected and counted.

Table 13. Species composition, size range and catch rate (averaged numbers fish per hour (standard deviation in brackets) of common fish sampled by boat electrofisher in Milipsigate Lake in July 15-16, 2013 (Catch rate – numbers per hour; SD – standard deviation).

Species	Catch (numbers)	Catch Rate (SD)	Fork Length (cm) Mean	Minimum	Maximum
Chain Pickerel	32	12 (23.4)	12.4	6.1	35.6
Smallmouth Bass	170	97 (44.1)	16.9	7.5	40.4
American Eel	57	24 (24.1)	39.0	37.0	41.0
White Perch	33	16 (25.3)	16.3	12.3	19.9
White Sucker	38	19 (12.4)	25.6	9.6	34.0
Yellow Perch	40	22 (16.8)	11.6	3.8	19.1
Golden Shiner	8		8.8	6.7	20.8

Table 14. Station characteristics, shock time and catch rate (averaged numbers fish per hour) of Smallmouth Bass sampled at ten sites in Minamkeak Lake by boat electrofisher on July 17-18, 2013 (SD: standard deviation).

Station	Estimated Percent of Station Covered by Vegetation	Maximum Water Depth (m)	Shock Time (seconds)	Catch Rate of Smallmouth Bass (numbers per hour)
11	90%	1.0	1154	84
12	90%	2.4	283	153
13	90%	1.2	377	48
14	20%	2.1	254	113
15	10%	1.2	194	167
16	1%	1.0	305	35
17	0%	1.2	230	110
18	90%	1.2	292	210
19	10%	1.2	231	140
20	10%	1.0	190	95
21	70%	1.2	522	41
22	70%	1.0	499	72
Mean Catch Rate (SD)				106 (54.1)

Table 15. Species composition, size range and catch rate (mean numbers of fish per hour (standard deviation in brackets) of common fish species sampled by boat electrofisher in Minamkeak Lake on July 17-18, 2013 (Catch rate – numbers per hour; SD – standard deviation).

Species	Catch (numbers)	Catch Rate (SD)	Fork Length (cm)		
			Mean	Minimum	Maximum
Smallmouth Bass	118	106 (54.1)	16.4	8.9	28.4
American Eel	34	21 (21.2)	NA	NA	NA
White Perch	85	61 (108.6)	12.5	7.5	20.5
White Sucker	14	10 (15.6)	24.4	8.7	33.2
Yellow Perch	44	32 (30.1)	12.5	3.5	20.2
Golden Shiner	23		10.4	7.0	13.6
Common Shiner	6		6.7	5.6	7.7
Banded Killifish	2		7.6	6.6	8.5
Brown Bullhead	3		21.9	21.0	22.4

FIGURES

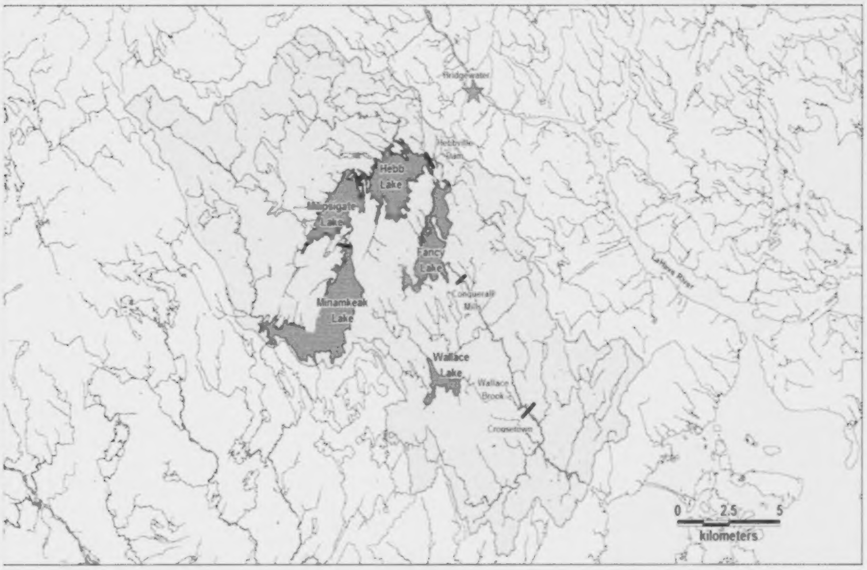

Bridgewater
Hebbville Dam
Hebb Lake
Milipsigate Lake
Fancy Lake
Conquerall Mills
Minamkeak Lake
Wallace Lake
Wallace Brook
Crousetown
LaHave River
0
2.5
5
kilometers

Figure 1. Location of the Petite Rivière and Hebb, Milipsigate and Minamkeak lakes. Black lines indicate location of dams in the Petite Rivière watershed.

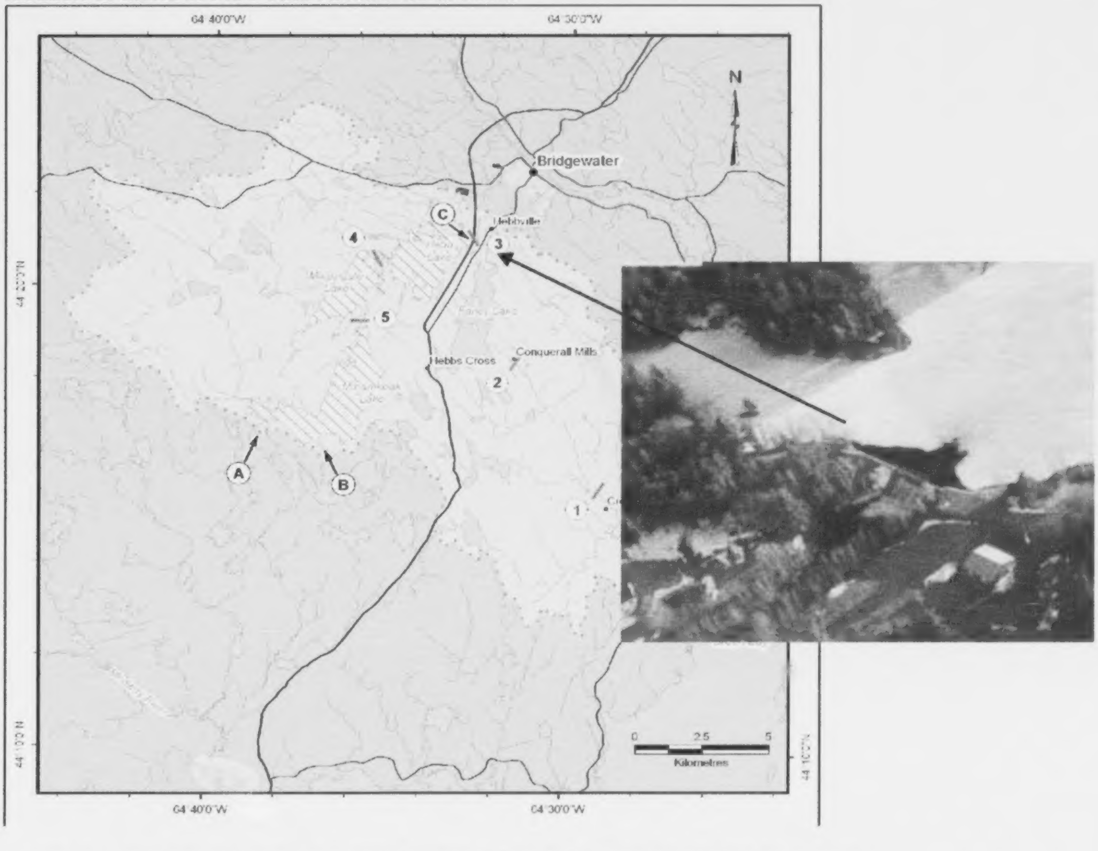

64°40'0"W
64°30'0"W
44°20'0"N
44°10'0"N
N
Bridgewater
C
Hebbville
3
4
5
Hebbs Cross
Conquerall Mills
2
A
B
1
0
2.5
5
Kilometres

Figure 2. Location of Hebb Dam and the fish passage facility (indicated by arrow).

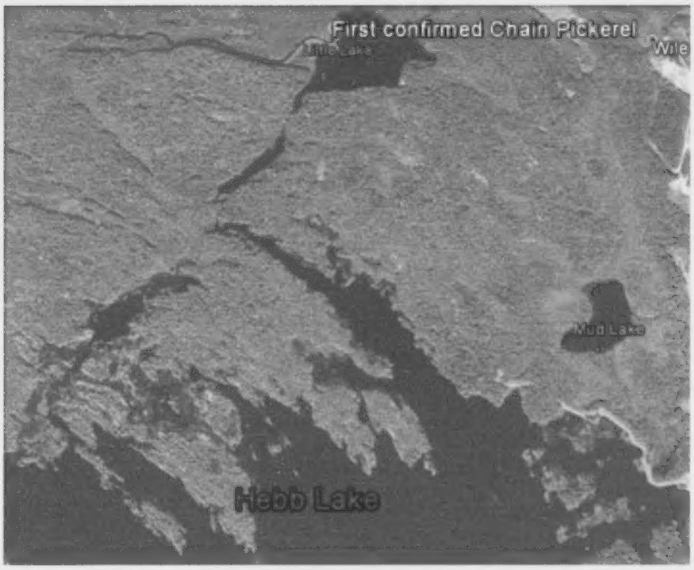

First confirmed Chain Pickerel
Little Lake
Wile
Mud Lake
Hebb Lake

Figure 3. Location of first confirmed capture of Chain Pickerel on May 17, 2013 in Little Lake which feeds into the northern end of Hebb Lake at bottom of image (image generated using Google Earth).

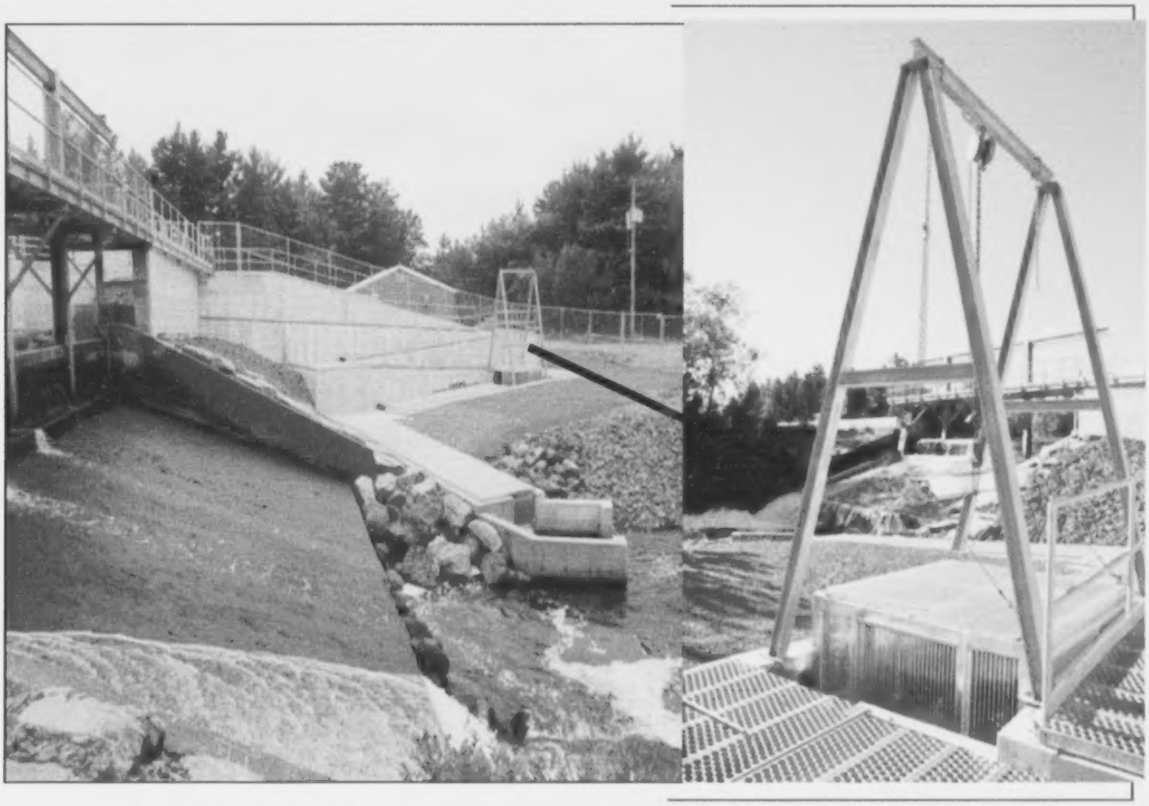


Figure 4. Hebb Dam fish passage facility. Left photo shows side view of dam and position of fish trap in one of the lower pools. Right photo shows close-up of fish trap partially raised.

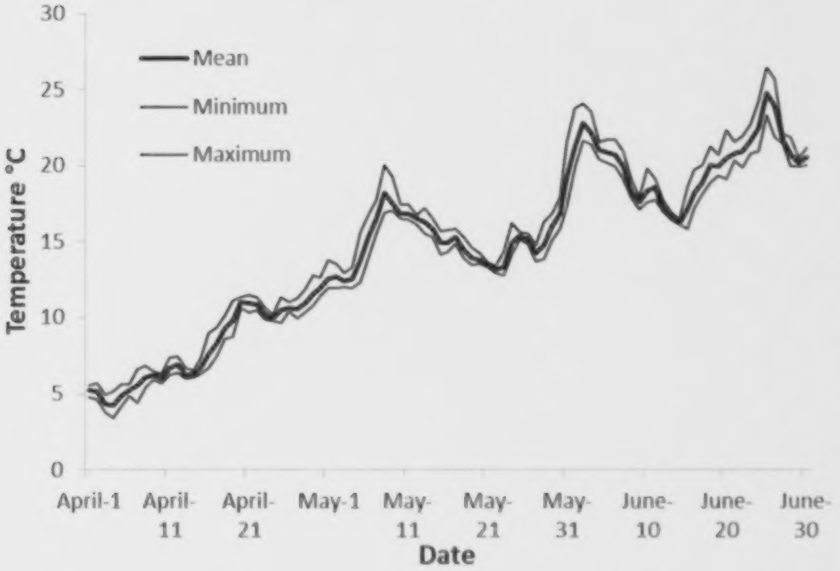


Figure 5. Mean, minimum, and maximum daily water temperatures (°C) in the fish passage facility at Hebb Dam from April 18 to June 30, 2013, recorded at 30 minute intervals.

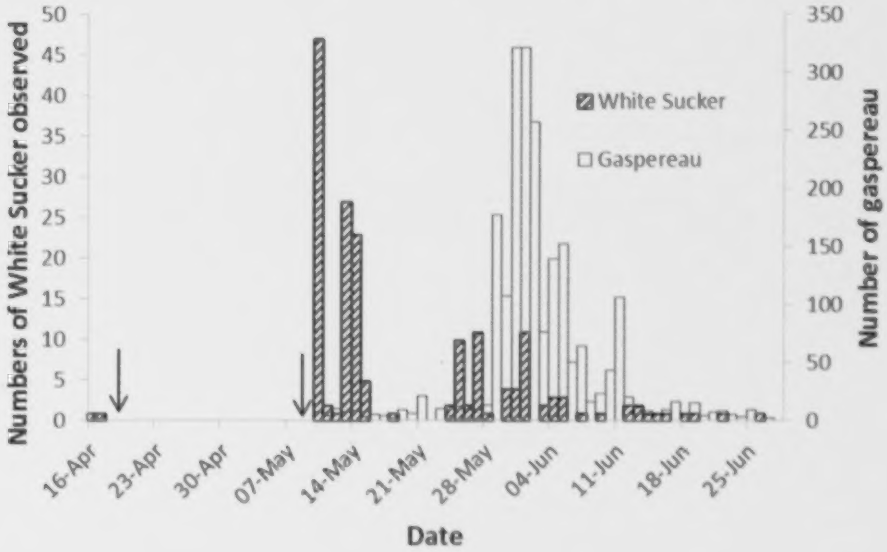


Figure 6. Daily catch (numbers) of White Sucker (left vertical axis) and gaspereau (right vertical axis) observed during daily monitoring of the Hebb Dam fishway April 16-19 and May10-June 28, 2013. Arrows indicate timing of fishway closing April 19 and reopening May 10.

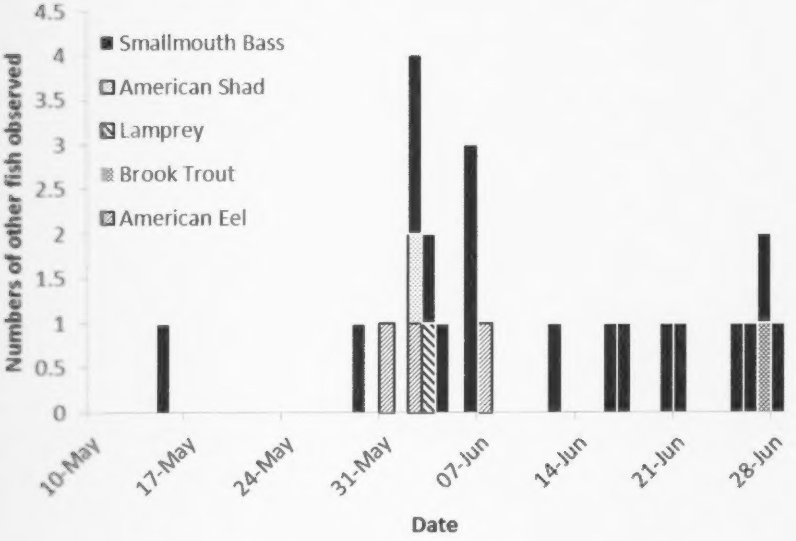


Figure 7. Timing of arrival of uncommon fish species at the Hebb Dam fish facility during daily monitoring in spring 2013.

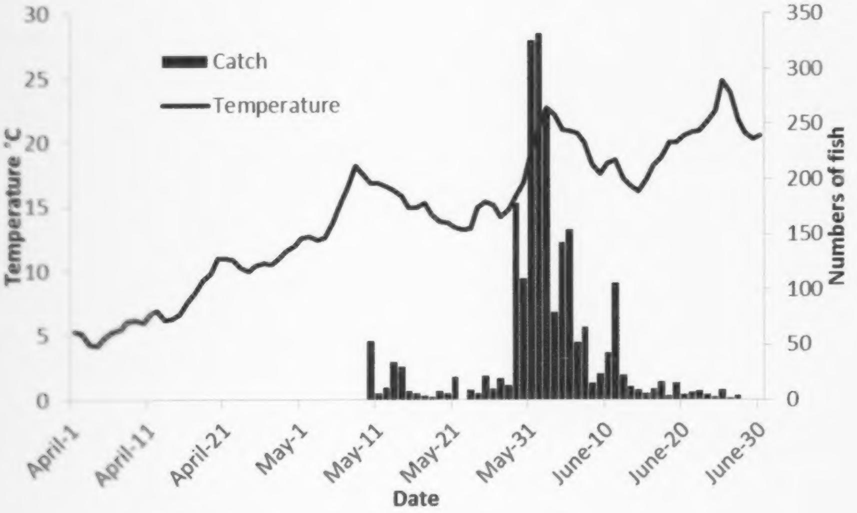


Figure 8. Mean daily temperature and occurrence of gaspereau at the Hebb Dam fish facility (fish way monitored April 16-19 and May 10-June 28, 2013.

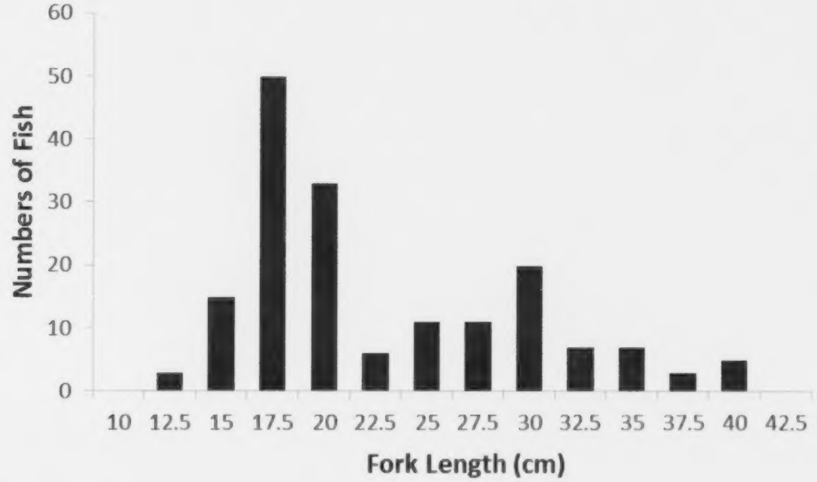


Figure 9. Fork Length (cm) frequency distribution of White Sucker caught in the Hebb Dam fish way trap during monitoring April 16-19 and May 10-June 28, 2013.

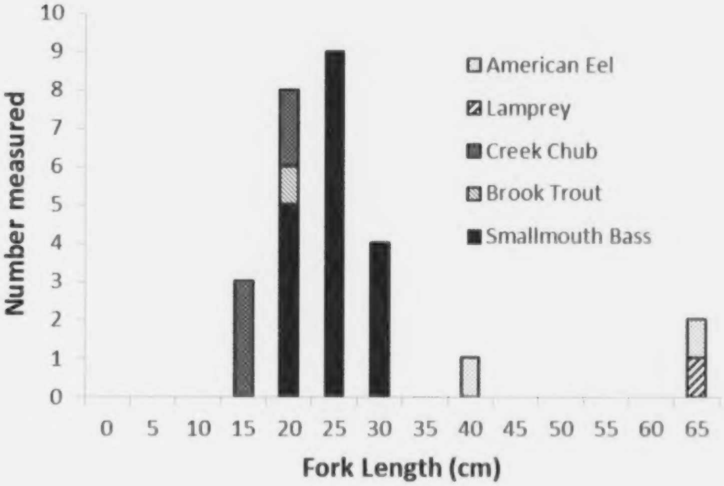


Figure 10. Fork Length (cm) frequency distribution of fish species caught infrequently in the Hebb Dam fish way trap April 16–June 28, 2013.

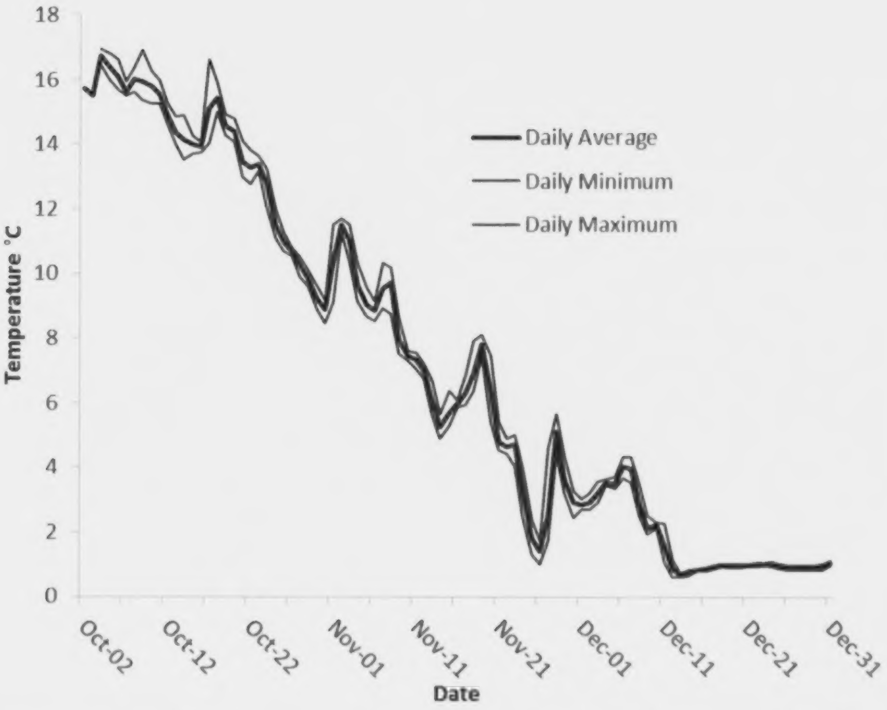


Figure 11. Mean, minimum and maximum daily water temperatures in the fish way at Hebb Dam October 1-December 1, measured and recorded at 30 minute intervals.

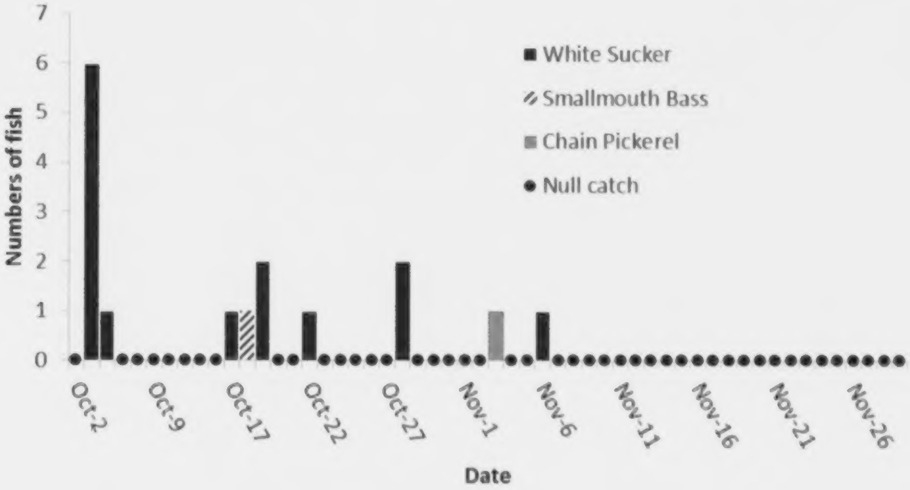


Figure 12. Species and number of fish observed in the fish way at Hebb Dam during operation from October 2-November 29, 2013. Null catch – no fish found in trap.

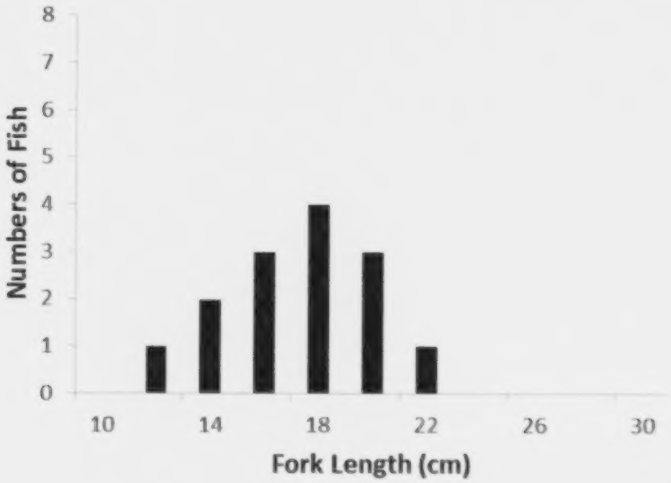


Figure 13. Fork Length (cm) frequency distribution of White Sucker caught in fish way at Hebb Dam during operation from October 2-November 29, 2013.

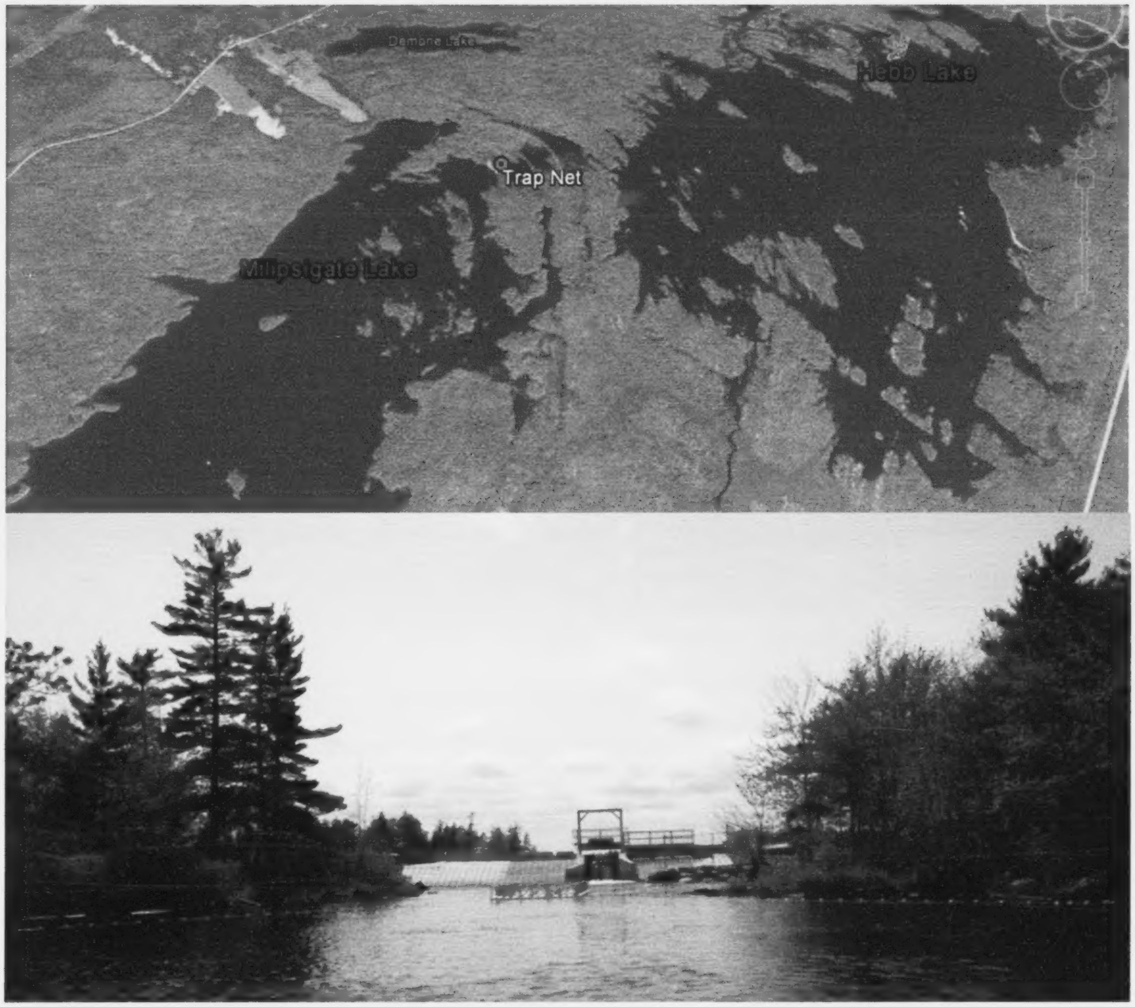

Damone Lake
Hebb Lake
Trap Net
Milipsigate Lake

Figure 14. Position of floating trap net set in Hebb Lake in the outlet below the Milipsigate Dam from May 29–June 15, 2013. Upper panel shows location of trap net (image generated using Google Earth). Bottom panel shows trap net photographed looking upstream at the dam between Hebb and Milipsigate lakes. Two leaders stretch in a V shape from the lake shores to the mouth of the trap.

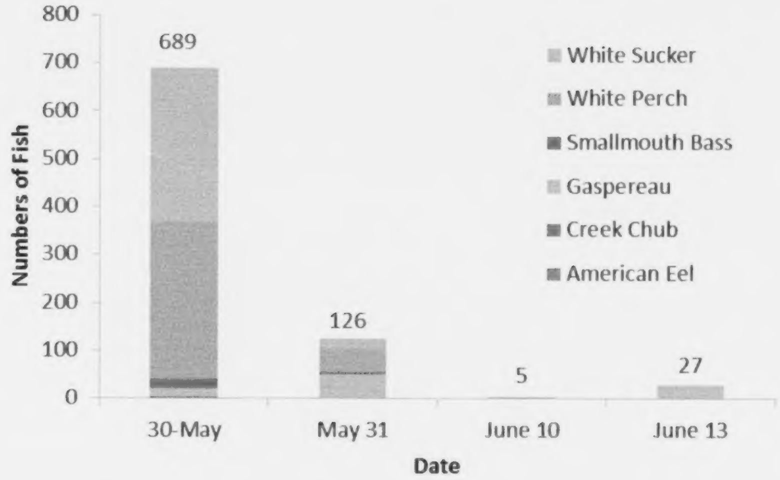


Figure 15. Dates of sampling and capture data for the trap net set in Hebb Lake at the base of Milipsigate Dam from May 5-June 13, 2013. Numbers above bars indicate total numbers of fish caught that day.

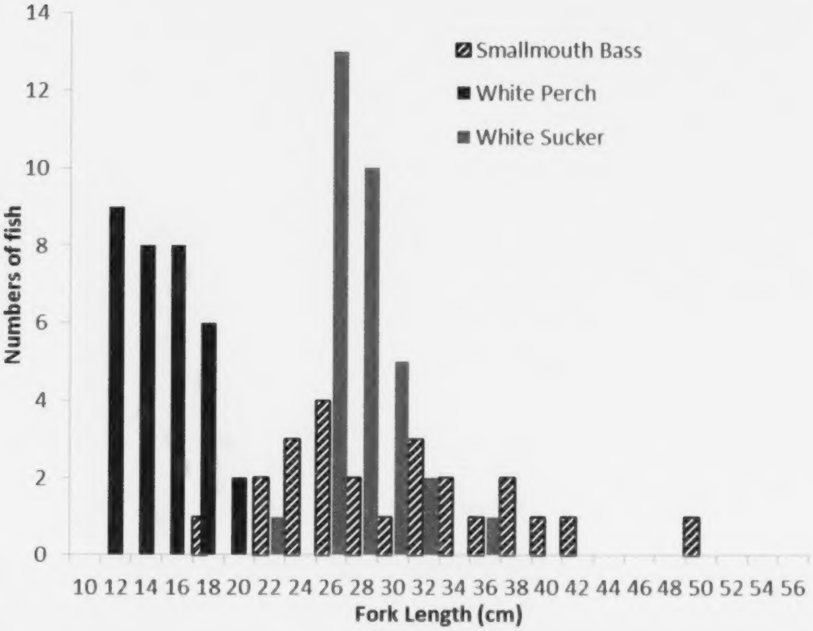


Figure 16. Fork Length (cm) frequency distribution of abundant species caught in trap net set in Hebb Lake below outflow from Milipsigate Dam from May 10-June 13, 2013.

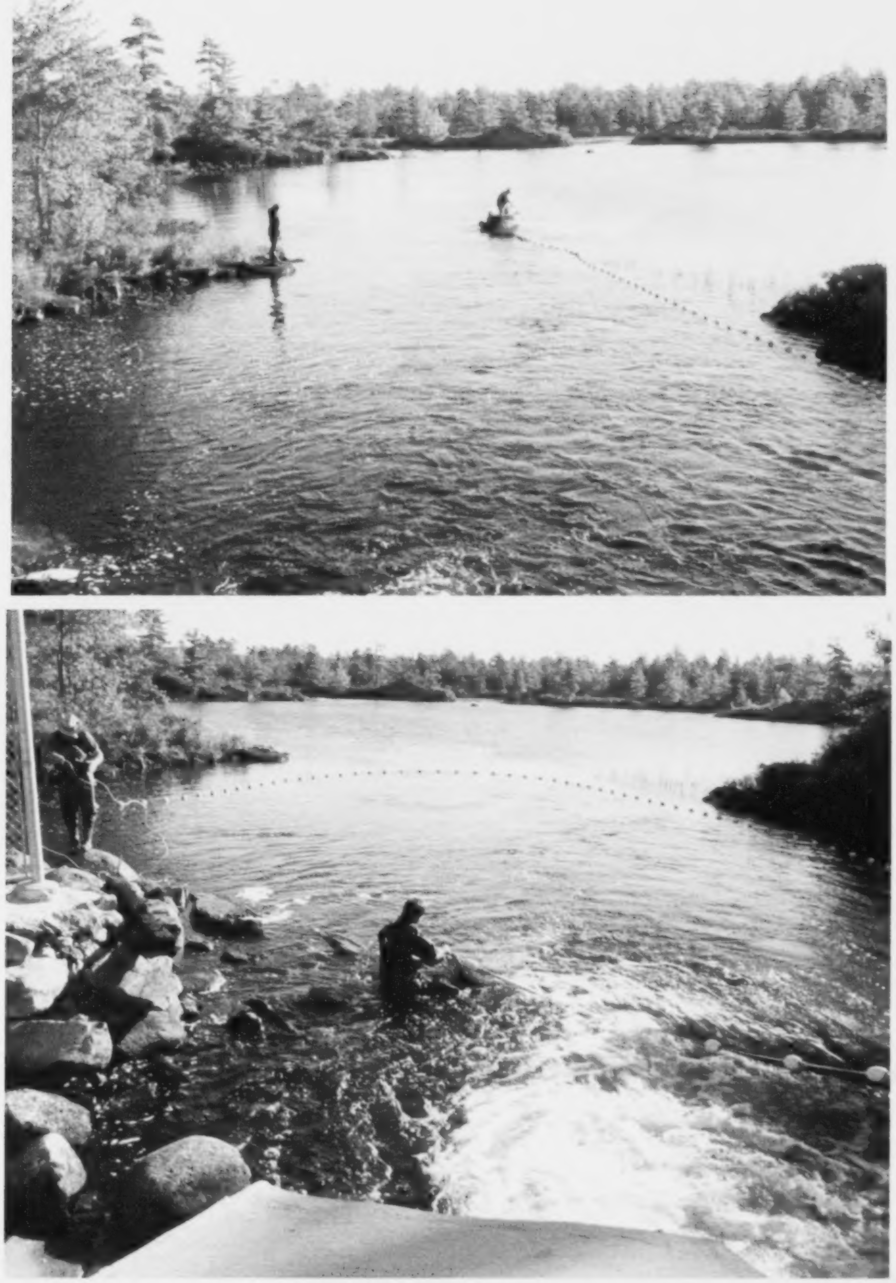


Figure 17. Photographs showing the seining operation in Hebb Lake in the outflow below Milipsigate Dam on Oct 3, 2013. Top photo: the seine is paid out along the right hand bank; lower photo, the pool has been encircled and the seine is being pursed on the left hand bank. Both photos are taken while standing and looking downstream into Hebb Lake.

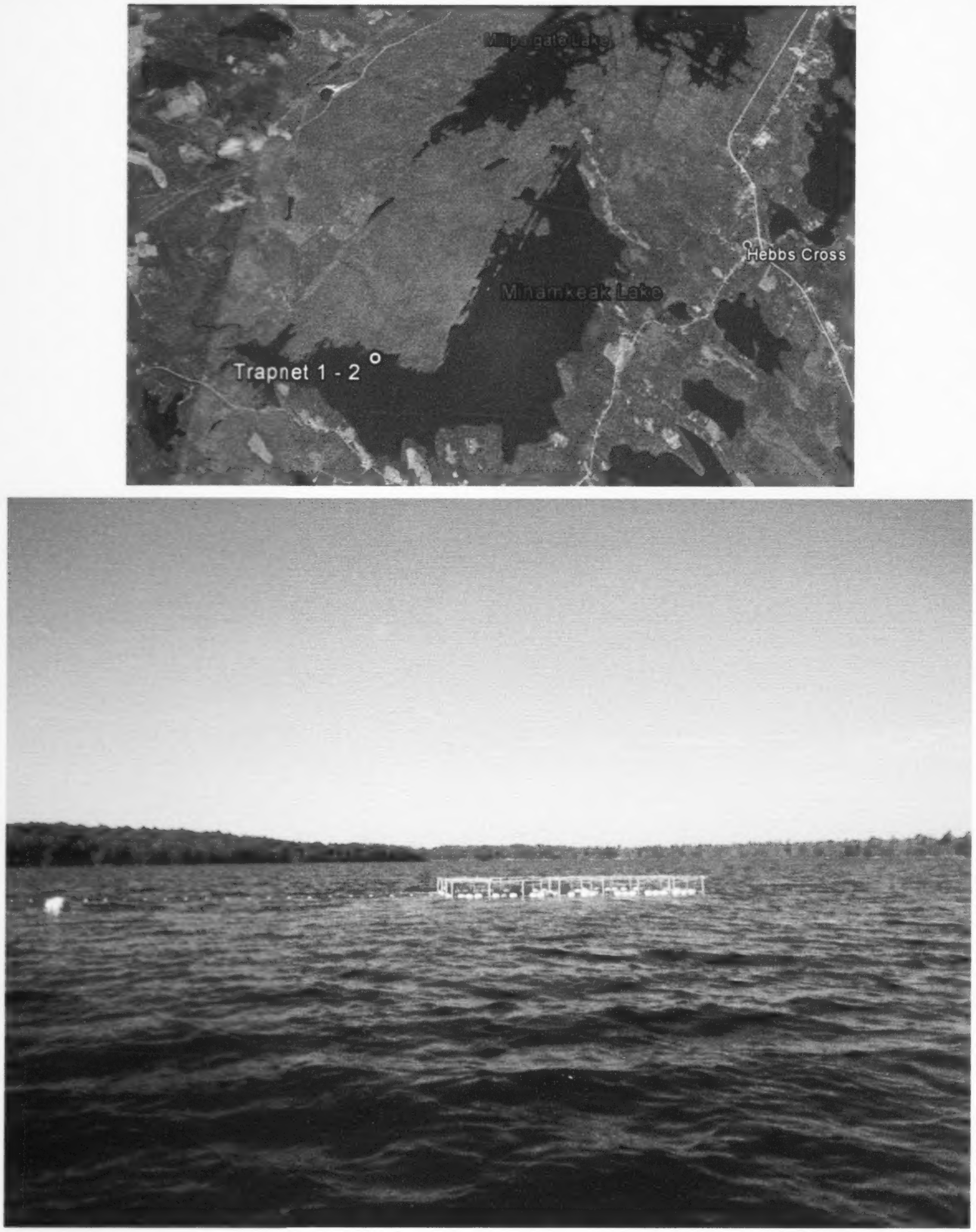

Milipsigate Lake
Hebbs Cross
Minamkeak Lake
Trapnet 1 - 2

Figure 18. Position of floating trapnets set in Minamkeak Lake from September 30–October 30, 2013. Top panel: Map showing location of traps in Minamkeak Lake (image generated using Google Earth); Bottom panel: view of the 3 m deep trap net set in Minamkeak Lake.

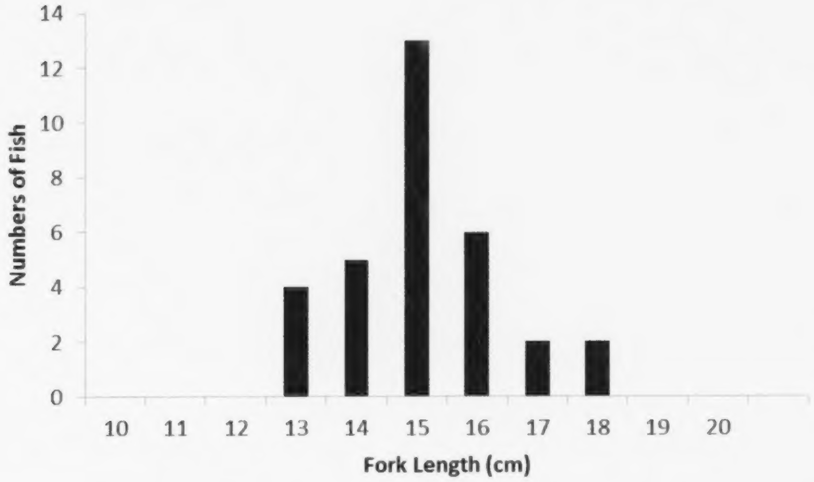


Figure 19. Fork Length (cm) frequency distribution of White Perch caught in trap nets in Minamkeak Lake from September 30–October 30, 2013.

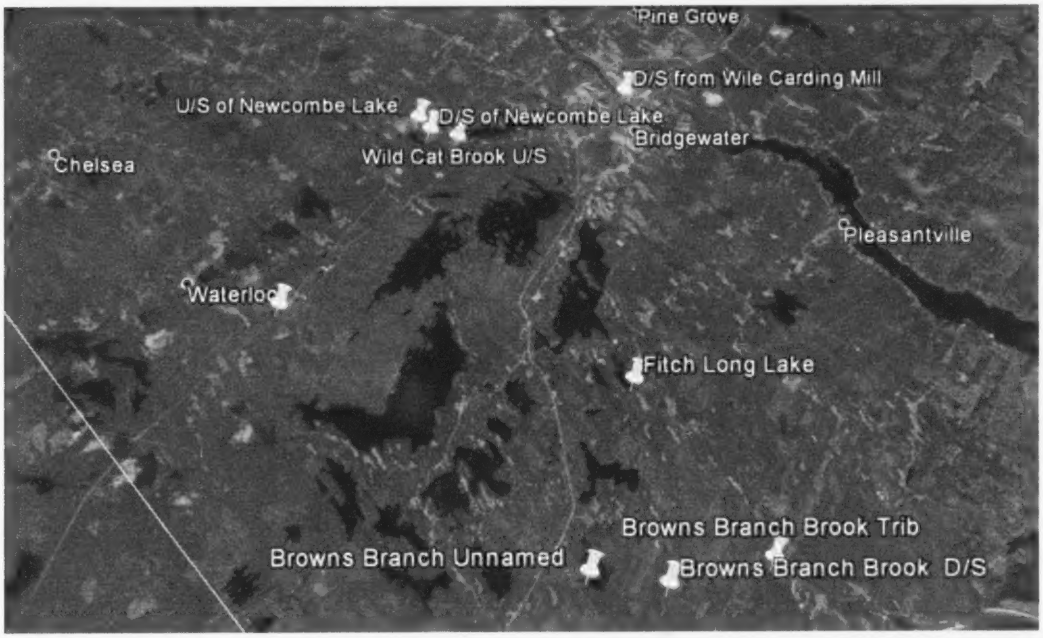

Pine Grove
D/S from Wile Carding Mill
U/S of Newcombe Lake
D/S of Newcombe Lake
Bridgewater
Chelsea
Wild Cat Brook U/S
Pleasantville
Waterloo
Fitch Long Lake
Browns Branch Brook Trib
Browns Branch Unnamed
Browns Branch Brook D/S

Figure 20. Locations where fish were collected for fish health testing.in April 2013 (image generated using Google Earth).

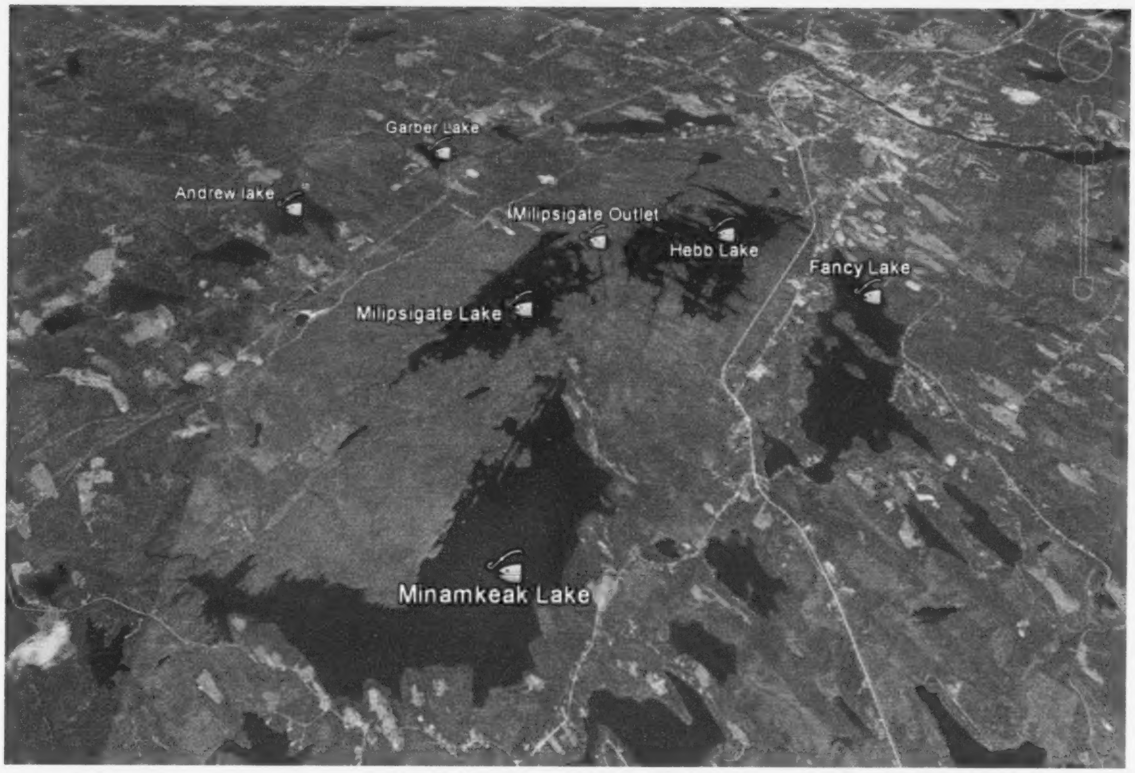

Garber Lake
Andrew lake
Milipsigate Outlet
Hebb Lake
Fancy Lake
Milipsigate Lake
Minamkeak Lake

Figure 21. Water bodies sampled for Smallmouth Bass and Chain Pickerel by angling in the upper lakes of the Petite Rivière watershed in 2013 (image generated using Google Earth).

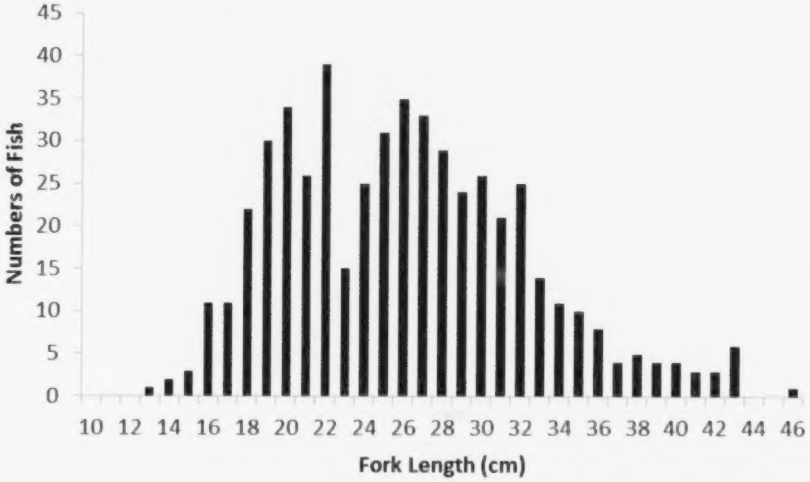


Figure 22. Fork Length (cm) frequency distribution of Smallmouth Bass (n=516) sampled by angling in the Petite Rivière watershed in 2013.

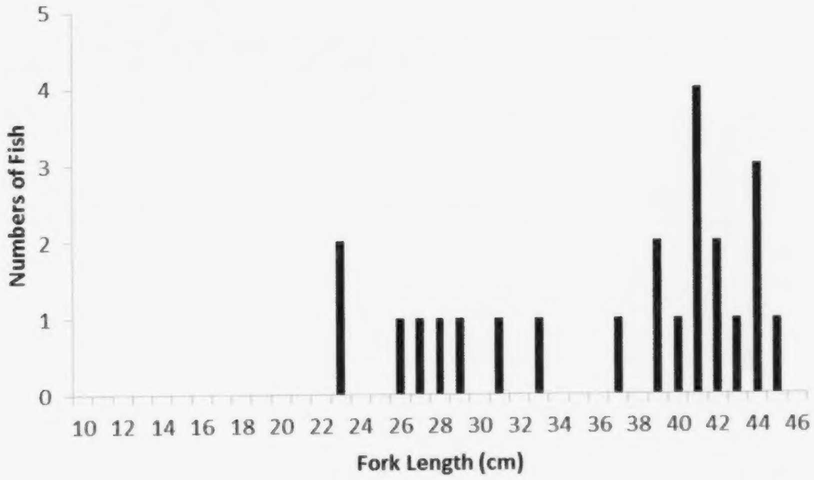


Figure 23. Fork Length (cm) frequency distribution of Chain Pickerel (n=23) sampled by angling in the upper Petite Rivière watershed in 2013.

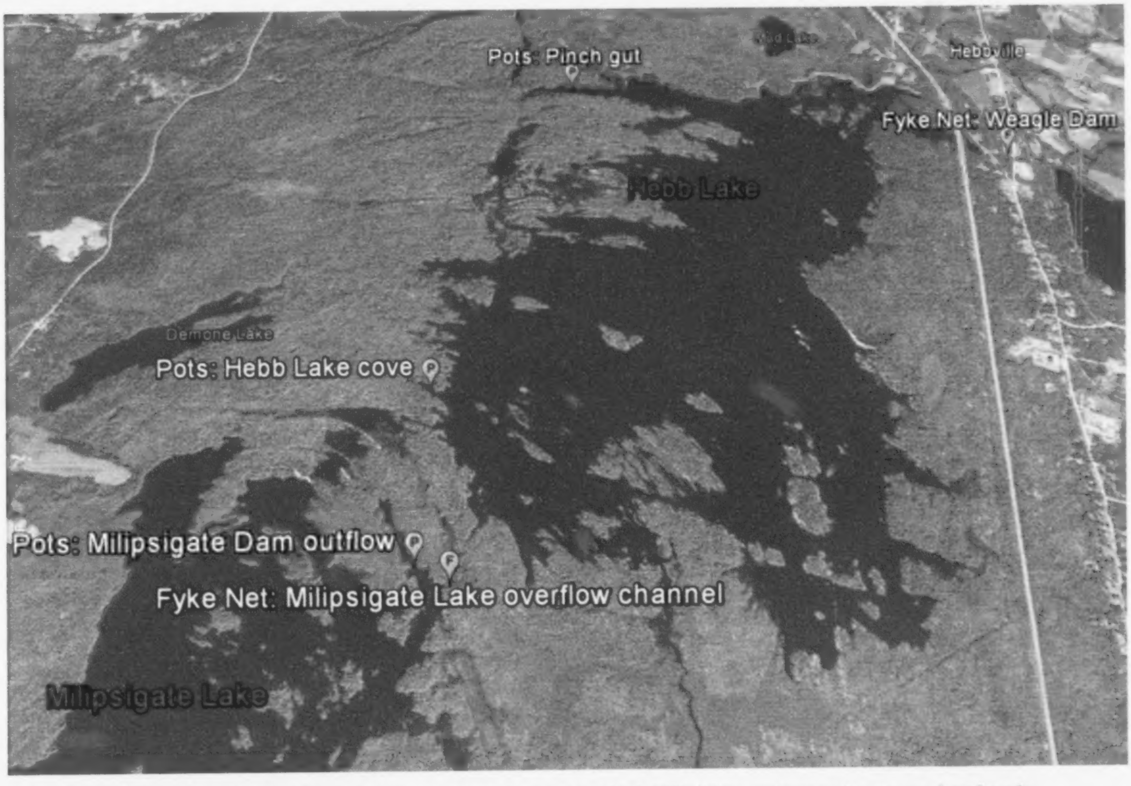

Pots: Pinch gut
Hebbville
Fyke Net: Weagle Dam
Hebb Lake
Demone Lake
Pots: Hebb Lake cove
Pots: Milipsigate Dam outflow
Fyke Net: Milipsigate Lake overflow channel
Milipsigate Lake

Figure 24. Locations in Hebb and Milipsigate lakes sampled with fyke, minnow traps and eel pots (labelled pots) in 2013 (image generated using Google Earth).

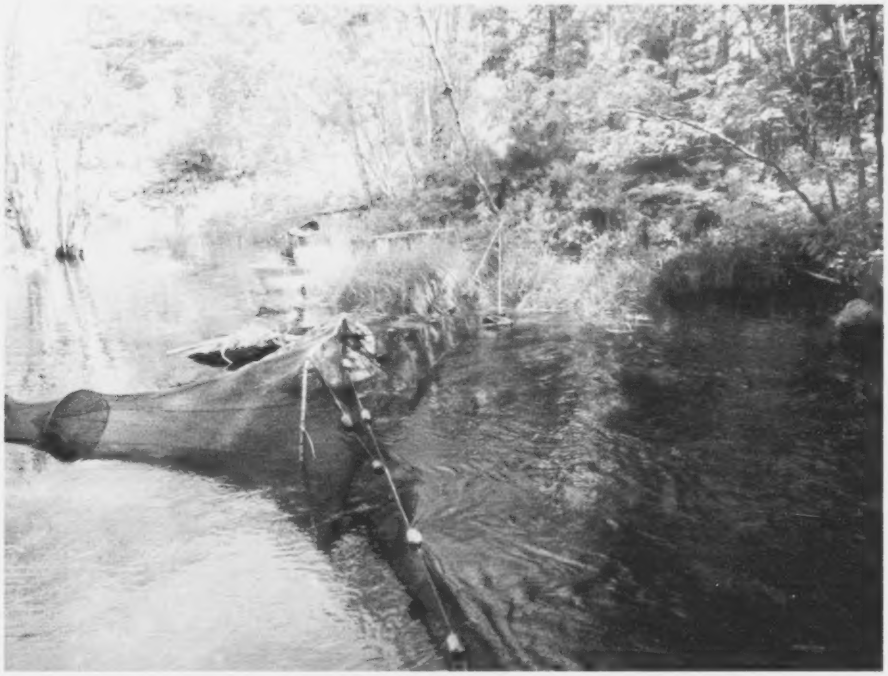


Figure 25. Side view of fyke net set in the Milipsigate Lake overflow channel between Milipsigate and Hebb Lakes from June 18-21, 2013.

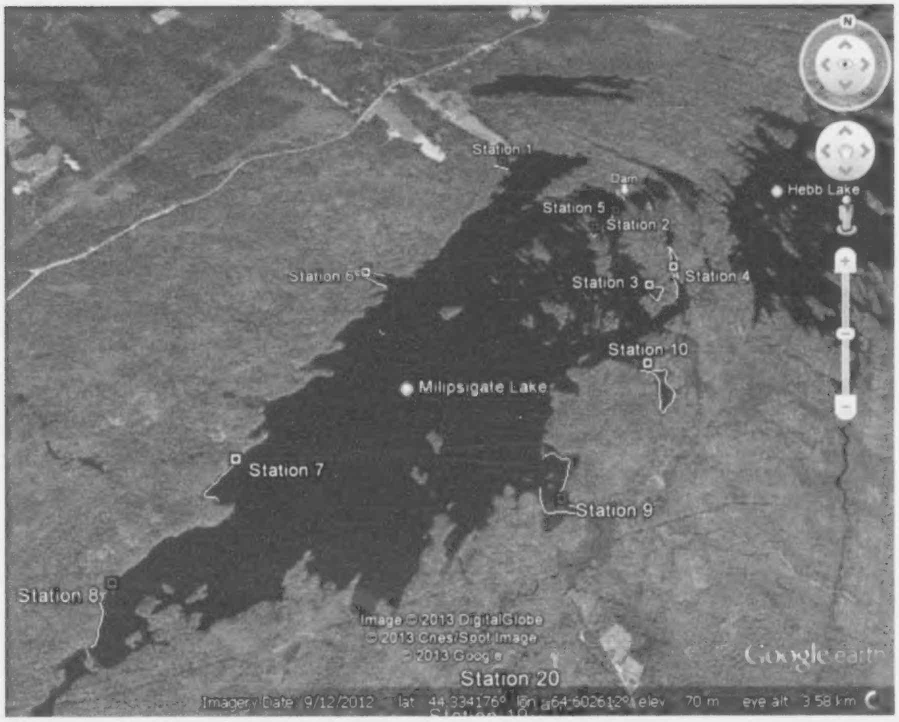

Station 1
Dam
Station 5
Station 2
Hebb Lake
Station 6
Station 3
Station 4
Station 10
Milipsigate Lake
Station 7
Station 9
Station 8
Image © 2013 DigitalGlobe
© 2013 Cnes/Spot Image
© 2013 Google
Station 20
Google earth
Imagery Date: 9/12/2012 lat 44.334176° lon -64.602612° elev 70 m eye alt 3.58 km

Figure 26. Location of sites sampled with a boat-mounted electrofisher July 15-16, 2013 in Milipsigate Lake (image generated using Google Earth).Dot indicating sampling site: yellow – positive for Chain Pickerel; red – no chain pickerel captured. White lines indicate pattern of sampling at that site.

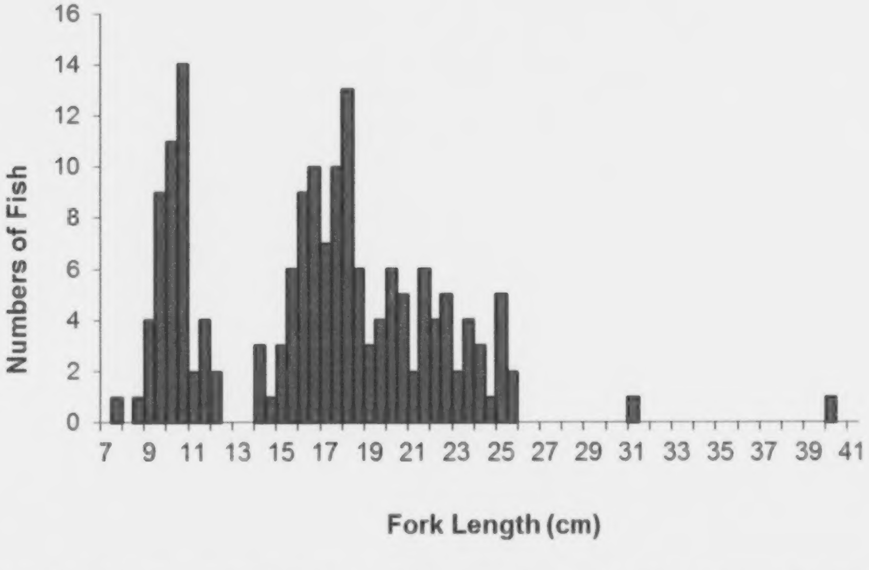


Figure 27. Fork Length (cm) frequency distribution of Smallmouth Bass (n=170) sampled by boat electrofisher in Milipsigate Lake July 15-16, 2013.

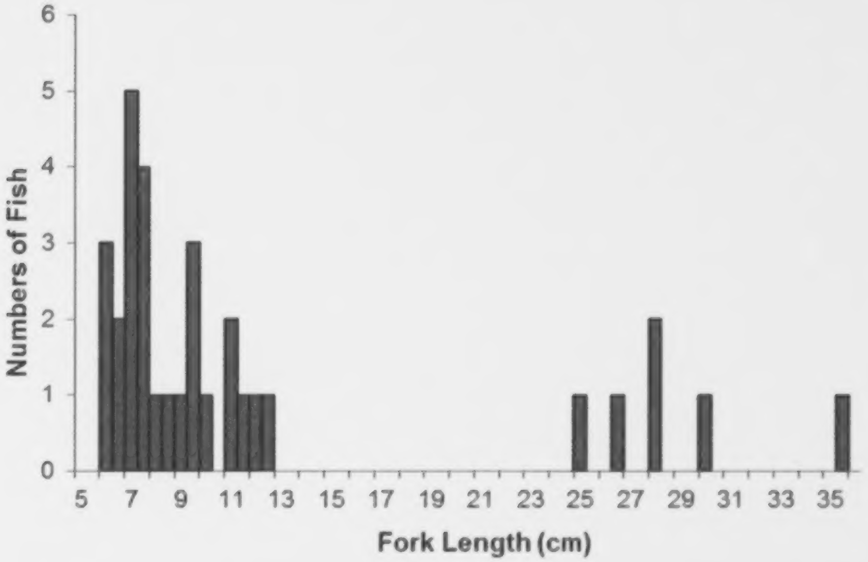
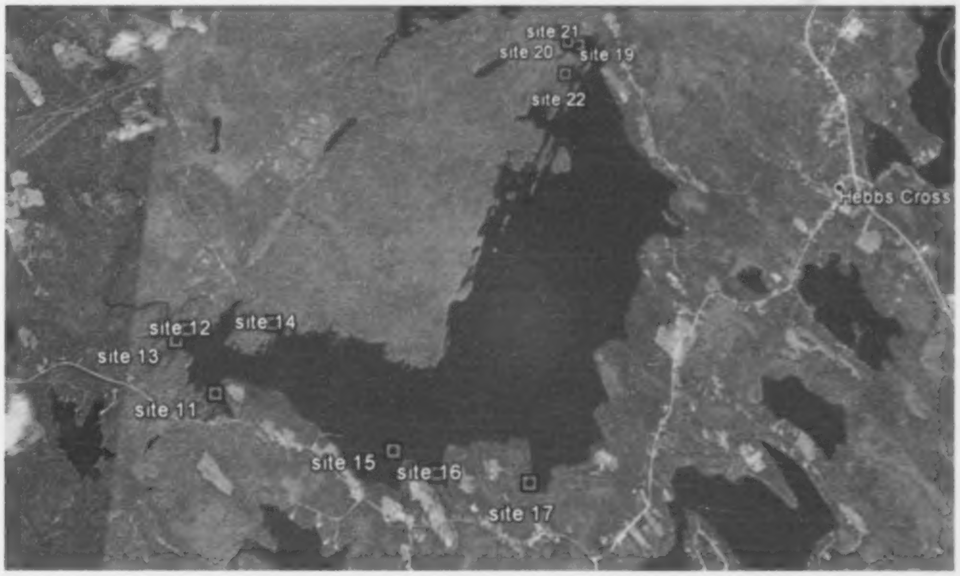


Figure 28. Fork Length (cm) frequency distribution (Fork Length (cm)) of Chain Pickerel (n=32) sampled by boat electrofisher in Milipsigate Lake July15-16, 2013.



site 21
site 20
site 19
site 22
Hebbs Cross
site 12
site 14
site 13
site 11
site 15
site 16
site 17

Figure 29. Location of sites sampled by boat electrofisher in Minamkeak Lake July 17-18, 2013 (image generated using Google Earth).

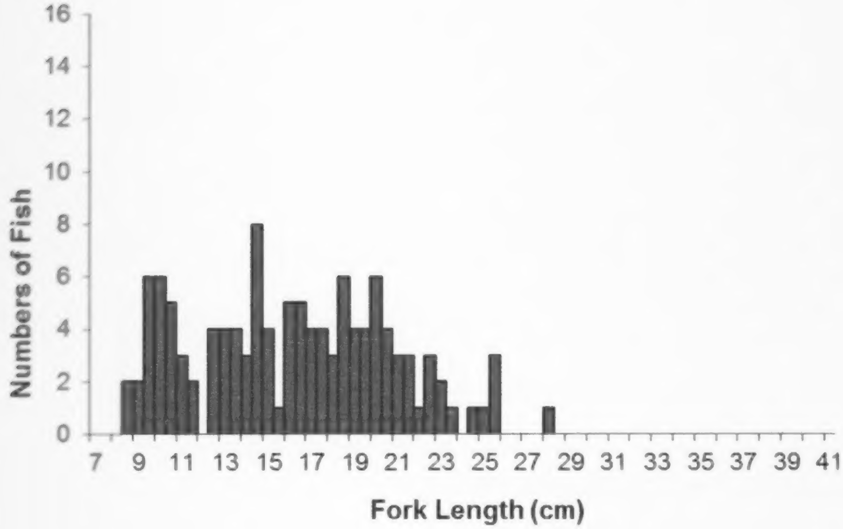


Figure 30. Fork Length (cm) frequency distribution of Smallmouth Bass (n=118) sampled by boat electrofisher in Minamkeak Lake July 17-18, 2013.

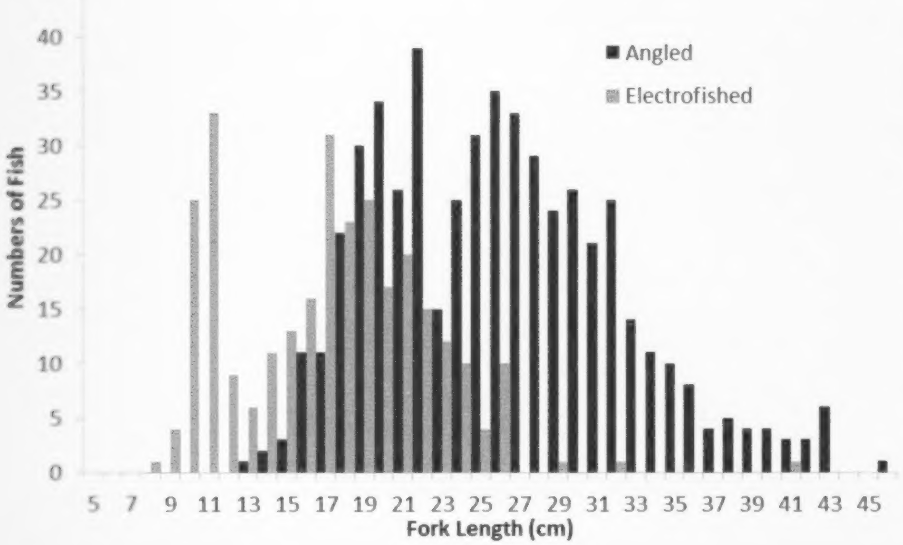


Figure 31. Comparison of Fork Length (cm) frequency distributions of Smallmouth Bass caught by angling (April-October, n = 516) and boat electrofishing (July 15-18, n=288) at all survey locations in the Petite Rivière watershed in 2013.

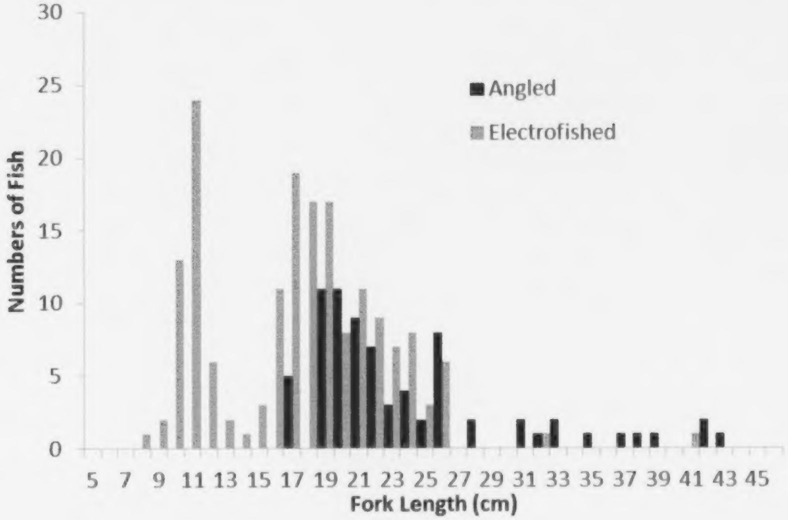


Figure 32. Comparison of Fork Length (cm) frequency distributions of Smallmouth Bass caught by angling (May-September, n=74) and boat electrofishing (July 15-16, n=170) in Milipsigate Lake in 2013.

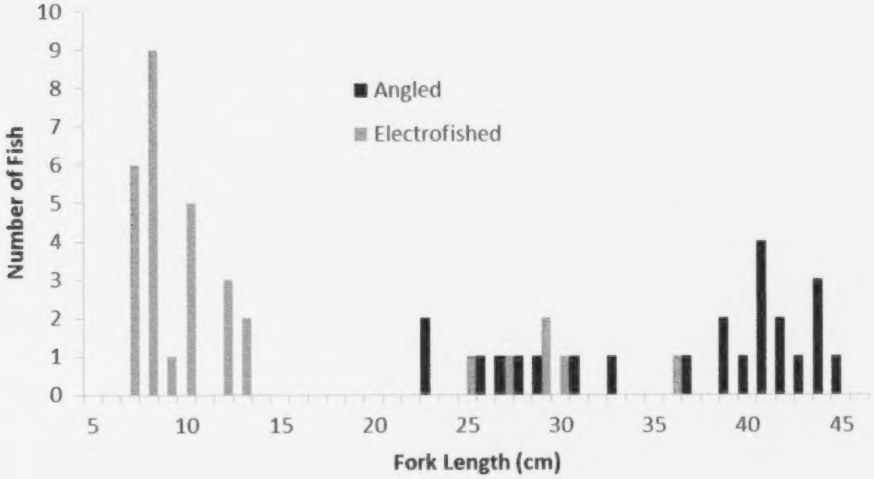


Figure 33. Comparison of Fork length (cm) frequency distributions of Chain Pickerel caught by angling (June-October, n = 23) and boat electrofisher (July 15-18, n = 32) at all survey locations in the Petite Rivière watershed in 2013.

APPENDIX 1: HEBB LAKE DAM FISH PASSAGE FACILITY INTERIM MONITORING PLAN UPDATE

Results of Fall 2012 Monitoring
Recommendations for Spring – Fall 2013

Updated by
Kimberly Robichaud-LeBlanc[1] and Shane O'Neil[2]

[1]Species at Risk Management Division
[2]Science
Fisheries and Oceans Canada, Maritimes Region

in collaboration with
the Atlantic Whitefish Hebb Dam Fish Passage Working Group

May 2013

Hebb Lake Dam Fish Passage Facility
Interim Monitoring Plan Update

- Results of Fall 2012 Monitoring and Recommendations for Spring - Fall 2013 -

BACKGROUND AND GOALS

Once anadromous, reproduction of the endangered Atlantic Whitefish (*Coregonus huntsmani*) (Figure 1) is currently restricted within three small semi-natural lakes in the upper Petite Rivière watershed in southwestern Nova Scotia (i.e., Minamkeak, Milipsigate and Hebb) (Figure 2). These lakes form the water supply for the Town of Bridgewater. A series of dams constructed over the past centuries along the main stem of the Petite Rivière and between the three headwater lakes, either block or impede fish passage. The dam across the outlet of Hebb Lake is the first dam at the foot of the three lakes and effectively blocks any upstream migration of fishes beyond this point (Figure 2, 3). Atlantic Whitefish individuals that fall over the Hebb Dam cannot return to the lakes where reproduction occurs and therefore represent a potentially significant loss of productivity to a species that probably numbers no more than a few thousand individuals in total.

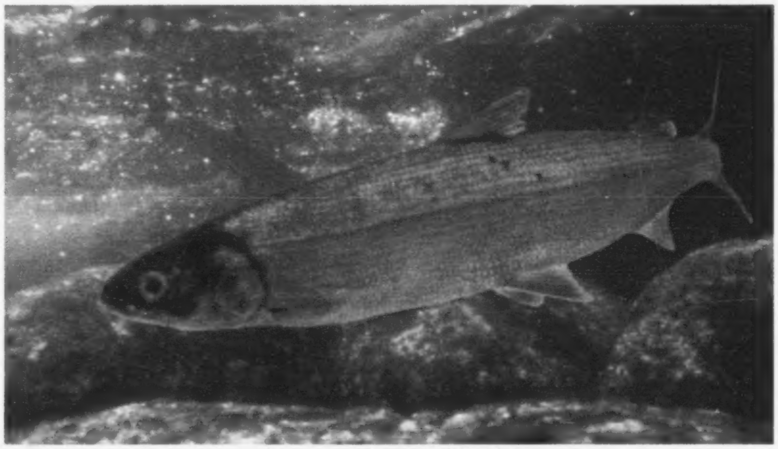


Figure 1: Atlantic Whitefish

Establishing fish passage at Hebb Lake Dam is deemed a significant step towards ensuring the survival of the wild Atlantic Whitefish population within the Petite Rivière lakes by allowing fish that have descended over the dam to return to Hebb Lake. The provision of fish passage at Hebb Dam also creates the conditions necessary to enable anadromy of Atlantic Whitefish on the Petite Rivière as supported by the Recovery Strategy and associated draft Action Plan. The provision of fish passage will also be beneficial to a number of other native diadromous species present in the watershed.

Construction of a fish passage facility at the Hebb Lake Dam by the Public Service Commission of Bridgewater (PSCB) began in summer 2011, and was completed in spring 2012 (Figure 4, 5). In preparation for the completion of the fish passage facility, DFO established in 2011 a working group of the Atlantic Whitefish Conservation and Recovery Team (AWCRT) to develop a phased interim monitoring plan (IMP) to include operational control protocols related to fish passage into Hebb Lake by various native and non-native fish species (Robichaud-LeBlanc and Fenton 2011[2]). With the fish passage facility in place at the Hebb Lake Dam, DFO installed a trap within the facility (Figure 5) to facilitate monitoring the passage of all fish species as per the IMP. Initially the facility was put in place to address some immediate concerns regarding the lack of fish passage at the site and loss of Atlantic Whitefish that have fallen over the dam to the lake population, and is intended to be used longer term to help address a number of key questions considerations related to Atlantic Whitefish recovery, including:

- Demonstrate that the facility is capable of allowing the passage of Atlantic Whitefish as well as other fish species to Hebb Lake.
- Contribute to a number of biological questions (such as habitat use, population size, movement and migration timing, biological characteristics and condition) related to Atlantic Whitefish and other fish species.
- Assess the feasibility of using the facility to control the numbers of fish per species entering the lake and/or prohibit entry of unwanted (e.g., invasive) fish species, if and when those controls may be required.
- Provide experience and information for fish passage needs around man-made barriers, or impediments, to fish passage both elsewhere on the Petite Rivière and elsewhere within the historical range of Atlantic Whitefish.

A phased and precautionary approach to fish passage is being conducted, with this interim monitoring plan (goals and operational controls) initially focused on allowing wild Atlantic Whitefish to return to Hebb Lake (Phase 1). Considering an ecosystem approach, the long term goal of the fish passage facility is to allow free passage to all wild, native fish species at the site; however, particular monitoring protocols, restrictions or removals may be appropriate for certain species.

The 2011 interim plan outlined the tasks in the later phases of monitoring, which could only be generalized at the time in that version of the document. The experience gained in Phase 1 and subsequent risk evaluation (Phase 2) was intended to allow the interim plan to be modified and updated for use by DFO Science and partner organizations. Building upon the experience gained at each phase, an ongoing evaluation of potential risks/impacts and interactions associated with the introduction of identified native and non-native fish species is required. Operational protocols for each phase in monitoring are to be determined to address all issues related to various species expected to be encountered at the facility, including captive-reared origin Atlantic Whitefish. A final long-term monitoring plan will be developed at a later date based on this experience (Phase 3).

---

[2] Robichaud-LeBlanc, K., and D. Fenton. 2011. Hebb Lake dam fish passage facility interim monitoring plan: fall 2011 – winter/spring 2012. Internal Rep. DFO Species at Risk Management Division, Maritimes Region, September 1, 2011, 13pp.

To assist with this, a Hebb Dam Fish Passage Working Group (Terms of Reference in Appendix 1.1) has been created to help DFO develop and implement this interim monitoring plan (Phase 1) and provide ongoing guidance related to fish passage into Hebb Lake and other facilities, once established.

FISH PASSAGE AND FISH ASSESSMENT FACILITIES: OWNERSHIP AND RESPONSIBILITIES

Fish Passage Facility

The fish passage facility (*i.e.,* fishway) at Hebb Lake Dam, 290 Century Drive, Hebbville Nova Scotia is a concrete structure consisting of 26 stepped pools with an overall length of approx. 80m (262.5') (Figure 5). The Public Service Commission of Bridgewater (PSCB) constructed the facility in 2011/12 to permit the free passage of fish pursuant to Section 20(1) of the *Fisheries Act.* As owner of the dam and fishway the PSCB is responsible for maintaining the fishway in good and effective condition and is responsible for any structural maintenance of the original structure. Other fishway operational requirements by PSCB, *e.g.* water levels and flows, are being determined in consultation with DFO as operational experience is gained with the fishway.

Fish Assessment Facility

The fish assessment facility (*i.e.,* fish trap) is an aluminum structure approximately 6ft. X 6ft. and 8 ft. high and is installed in the lower section of the fishway (Figure 5, 6 and 7). DFO Science maintains ownership of the fish trap installed within the fishway, and is responsible for its design, construction, installation, maintenance and any future modifications. DFO Science is also responsible for the overseeing the fish trap operations, which can include the participation of other partner organizations, such as the Bluenose Coastal Action Foundation (BCAF) who conducted the monitoring in 2012.

The PSCB does not assume responsibility for the design, construction or purchase of any trapping or monitoring equipment required for the operation of the fish trap nor does it assume responsibility for any future modifications of the fish trap. The PSCB does not assume any responsibility for any costs associated with monitoring fish passage at the facility.

MONITORING GOALS AND PROTOCOLS – A MULTI-PHASED APPROACH

A precautionary and phased approach to monitoring at the Hebb Dam fishway was taken for the first year in order to allow for a more in-depth evaluation of a), the efficiency of the fishway and b) the potential risks associated with access into Hebb Lake of identified native and non-native fish species. The following phased interim monitoring plan and operational controls were implemented for the fall 2011 – winter/spring 2012 season based on known migration timing of identified native and non-native fish species in the Petite Rivière watershed.

PHASE 1 (Fall 2012): Passage of Wild Salmonids (Atlantic Whitefish, Brook Trout and Atlantic Salmon) and American Eel

The fishway and fish trap were expected to be in place in the fall 2011 period (i.e. October – November), however construction of the fishway was not completed until spring 2012. The fishway opened after another delay due to waiting for fish health screening results and until water levels were optimal for operation. The trap was operated from September 24 to December 12, 2012 by the Bluenose Coastal Action Foundation respecting the following general practices and requirements:

- Monitoring frequency - daily as per recommendations from DFO Science.
- Monitoring duration - dependent of fish captures and recommendations from DFO Science; extended until December 12 in 2012
- All Atlantic Whitefish (wild and captive-reared) intercepted in the fish trap were counted and sampled but only wild Atlantic Whitefish were allowed to ascend into Hebb Lake during this phase;
- As the trap design does not impede the upstream migration of American Eels of most sizes, all intercepted eels were allowed to ascend into Hebb Lake after sampling;
- Samples of Brook Trout were acquired from both above and below the Hebb Dam prior to the opening of the fishway in 2012 and sent to Fish Health Unit, DFO Gulf Region for fish health testing. No fish health concerns were noted;
- All other species intercepted in the assessment facility were counted and sampled during the time period of operation, and either sacrificed or fin clipped (to monitor repeat captures at the fish trap) and allowed access to or returned to below Hebb dam as per the September 2011 Operational Controls Protocols and taking results of disease testing into consideration. Adjustments to the Operational Controls Phase 1 set in 2011 (below), thus allowed for all wild salmonid species (Atlantic Whitefish, Brook Trout and Atlantic Salmon) passage into Hebb Lake in 2012;

Operational Controls Phase 1 (as set in September 2011 prior to disease testing results)

Below is a list of all potential relevant fish species in the Petite Rivière system and the proposed interim protocols for Phase 1.

Table 1.

Species	Protocol	Sampling Considerations
Wild Atlantic Whitefish *(Coregonus hunstmani)*	Identify as wild, sample and allow passage into Hebb Lake	Identify as a wild fish if it does not possess the captive-reared markings described below. Apply an external mark, record biological information, extract scale samples for ageing and tissue samples for later genetic assessments
Captive-reared Atlantic Whitefish *(Coregonus hunstmani)*	Identify as captive-reared, sample and return to below dam	Identify as a captive-reared fish (adipose fin markings or a red or pink VIE[3] mark on the left pectoral), record biological information, extract scale samples for ageing and tissue samples for later genetic assessments, fin clip, subsample for fish health screening
American Eel *(Anguilla rostrata)*	Sample and allow passage into Hebb Lake	Record biological information, subsample for fish health screening
Smallmouth Bass *(Micropterus dolomieu)*	Sacrifice, provide to NS DFA for science purposes	Record biological information, extract scale samples for ageing and tissue samples for use in later genetic assessments, fin clip, subsample for fish health

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[3] VIE: Visible Implant Elastomer is an internal coloured tag that is visible externally.

		screening
Atlantic Salmon – wild (adults and juveniles) *(Salmo salar)*	Sample and return to below dam	Record biological information, extract scale samples for ageing, collect a tissue sample (lower caudal punch) for later genetic assessments. Submit mortalities for fish health screening.
Atlantic Salmon - Aquaculture Escapee *(Salmo salar)*	Sacrifice or sample and return to below dam – see sampling considerations	If clearly obvious escapee (*i.e.*, broom tail, severe fin erosion, odd body shape), sacrifice the fish and send to fish health for disease screening. Any other fish of limited odd characteristics to be sampled as per wild Atlantic salmon considerations above and the envelope marked possible aquaculture escape and returned below the dam.
Brook Trout (*Salvelinus fontinalis)*	Sample and return to below dam	Record biological information, extract scale samples for ageing and tissue samples for use in later genetic assessments, fin clip, sub-sample for fish health screening
Rainbow Trout escapees (*Oncorhynchus mykiss)*	Sacrifice, provide to NS DFA for science purposes	
Others (*e.g.*, White Perch, Yellow Perch, White Sucker, Brown Bullhead, etc.)	Sample and return to below dam	Record biological information, subsample for fish health screening
Alewife (*Alosa pseudoharengus)*	Not expected to arrive before spring, protocols will be established in Phase 2	

Blueback Herring *(Alosa aestivalis)*	Not expected to arrive before spring, protocols will be established in Phase 2	
Sea Lamprey *(Petromyzon marinus)*	Not expected to arrive before spring, protocols will be established in Phase 2	

Roles and Responsibilities – Phases 1 & 2

The respective roles and responsibilities as set in the September 2011 Interim Monitoring Plan and this 2013 update will likely continue to evolve as work progresses in each of the phases presented in this monitoring plan. The following represents the roles and responsibilities in the early phases.

Project Lead: DFO Science was responsible for leading the trap construction, overseeing the monitoring requirements including establishing the monitoring frequency, data collection protocols, reporting, etc. in 2012. It is expected DFO Science will continue to coordinate any of these operational requirements, including with NGO collaborators (e.g., BCAF, as required). DFO Science is also responsible for facilitating the shipment of samples collected to the Fish Health Unit, DFO Gulf Region, Moncton, NB, for health screening analysis in 2013.

Other Roles and Responsibilities:

- DFO SARMD will continue to be responsible for leading and coordinating the development and revisions of interim and long term monitoring plans in collaboration with the Atlantic Whitefish Hebb Dam Fish Passage Working Group. DFO SARMD also funded the trap construction including facilitating/coordinating the contract elements for the trap construction and installation in 2011/12. SARMD worked with Science to identify the staffing requirements and options for operating the trap in 2012.
- DFO Science, in addition to being the project lead and trap owner (see above), is responsible for leading the risk evaluation and drafting the risk evaluation framework (as required in Phase 2).
- DFO Fisheries Protection Program (FPP) is responsible for ensuring that the fish passage facility complies with the *Fisheries Act* and developing any agreements or legal requirements that may be required for operation and maintenance of the fish passage facility.
- The Hebb Dam Fish Passage Working Group is responsible for those elements identified under their Terms of Reference (Appendix 1.1).
- The Hebb Dam Fish Passage Working Group Chair is responsible for updating the broader Recovery Team on plans and actions related to fish passage at Hebb Dam.

Permit and Licence Requirements – Phase 1

Considering DFO owns the trap, only wild Atlantic Whitefish were expected to be allowed passage in Phase 1, and a third party (*i.e.*, BCAF) conducted the monitoring in 2012, the following permit and licence requirements were expected to apply and were obtained:

- A *Species at Risk Act* s.73 permit to DFO Science and for a third party (i.e., BCAF) for the handling and retention of Atlantic Whitefish
- No additional licence was required in 2012 as DFO is already authorized to operate a fish trap under their *Fishery (General) Regulations* s.52 scientific licence.
- A *Fishery (General) Regulations* s.52 licence will be required in 2013 with permission to remove smallmouth bass as a licence condition included.

These permit and license requirements, and any additional ones, will be revisited and obtained as required in subsequent phases.

PHASE 2 (Spring - Fall 2013): Review of Phase 1 Results and Risk Evaluation

Phase 2 involves a review of results from the fall 2012 monitoring and drafting of a risk evaluation framework. The risk evaluation was completed in 2013 (see Appendix 2: Qualitative review of the risks of providing fish passage via a fishway into Hebb Lake, Petite Rivière, Nova Scotia: Review of the risk of passing diadromous fish and other river-resident fish into the river above Hebb Dam). The review of the fall 2012 results includes a determination of the adequacy of the acquired data (in the event that not enough samples are acquired during the first fall of operation of the fishway and fish trap) to move forward in undertaking the risk evaluation or if additional data in a second year of monitoring will be needed. Phase 2 also involves the identification of potential risk associated with additional species expected to be at the facility in the spring. The following elements were undertaken in this second phase. Results from 2012 and recommendations for 2013 are outlined:

1. Review by the Hebb Dam Fish Passage Working Group of the results of the Phase 1 monitoring to ensure the information acquired is sufficient to undertake the risk evaluation or if additional data is required from a second year of monitoring.

Results:

Monitoring Summary Results Fall 2012

Species	Origin	Count	Passage Status
Atlantic Whitefish	Wild	18	Allowed upstream
Atlantic Whitefish	Hatchery	1	Returned downstream
American Eel	Wild	2	Allowed upstream
Atlantic Salmon	Wild	4	Allowed upstream

Brook Trout	Wild	12	Allowed upstream
Smallmouth Bass	Wild	3	Sacrificed
White Perch	Wild	2	Returned downstream
White Sucker	Wild	36	Returned downstream

Recommendations:
Monitoring results in 2012 are deemed sufficient to proceed with the risk evaluation

2. DFO Science incorporates the results of Phase 1 (including fish health screening) into a draft risk evaluation framework. This will include updated proposed operational protocols for all relevant fish species, including those expected to be at the facility during the spring months, *e.g.,* alewives, and blueback herring.

   Results and Recommendations:

   - Fish health screening was accomplished in the spring 2012 using Brook Trout as a surrogate. Samples were collected from both above and below Hebb Dam and sent to the Fish Health Unit in Gulf Region for analysis. No fish health concerns were noted. These results allowed the interim protocols set in September 2011 to be adjusted to allow passage of all wild salmonids (i.e., Atlantic Whitefish, Brook Trout, Atlantic Salmon) intercepted in the fish trap in fall 2012.

   - It was suggested that additional fish health screening (again using samples of Brook Trout captured both above and below Hebb Dam) continue prior to the spring 2013 season as a due diligence measure. Accordingly, Brook Trout from below and above Hebb Lake Dam were collected and sent to the Regional Fish Health office in April 2013. The fishway has been kept closed through April. Results from the disease testing were received in mid-May and indicated no bacterial or viral pathogens of concern. It is recommended that the fishway be opened once the fish health test results are returned if the testing is clear. Operation of the fishway is to be according to the revised operational protocols (Table 2).

   - An overview of issues associated with establishing escapement targets for alewife to Hebb Lake, a proposed basis for defining acceptable upper and lower bounds around an escapement target and recommendations on an appropriate escapement target was presented at the spring 2012 recovery team meeting (see minutes for details). The recommendation was for 20,000 spawners which represents about 2% of the estimated carrying capacity of Hebb Lake (950,000 spawners) in the absence of a fishery. There was overall concurrence from the recovery team on the recommended upper limit of 30,000 alewife pending other species interceptions at the time of the alewife run.

- Operational protocols to guide fishway operation in 2013 and beyond have been revised from those prepared prior to the 2012 fish migration season (Table 2).

3. Review of proposed draft risk framework by the Hebb Dam Fish Passage Working Group to determine whether the framework fulfills the aims and intents of a risk assessment as applied to introductions of aquatic species, e.g. such as the *Introductions & Transfers of Aquatic Organisms* license process.

   Results and Recommendations:

   - Fisheries and Oceans Science provided a risk review using the *Introductions & Transfers of Aquatic Organisms* framework to guide the fish passage at the Hebb Dam fishway (attached as Appendix 2).
   - The risk evaluation was reviewed by the Hebb Dam Fish Passage Working Group on May 16, 2013.

4. Revise interim monitoring protocols and operational controls as per risk evaluation results.

Table 2. *Revised Operational Controls – Season 2 (Spring – Fall 2013)*

Species	**Protocol**	**Sampling Considerations**
Wild Atlantic Whitefish *(Coregonus hunstmani)*	Identify as wild, count, sample and allow passage into Hebb Lake	Identify as a wild fish if it does not possess the captive-reared markings described below. Apply an external mark, record biological information, extract scale samples for ageing and tissue samples for later genetic assessments. Apply PIT tag as directed by DFO Science.
Captive-reared Atlantic	Identify as captive-reared, count,	Identify as a captive-reared fish

Whitefish *(Coregonus hunstmani)*	sample and return to below dam	(adipose fin markings or a red or pink VIE[4] mark on the left pectoral), record biological information, extract scale samples for ageing and tissue samples for later genetic assessments, fin clip, subsample for fish health screening.
American Eel *(Anguilla rostrata)*	Count, sample and allow passage into Hebb Lake	Record biological information
Smallmouth Bass *(Micropterus dolomieu)*	Count, sample and sacrifice	Record biological information, extract scale samples for ageing. Provide to NS DFA for science purposes
Other non-native fish species (e.g., Chain Pickerel (Esox niger)**)**	Count, sample and sacrifice	Record biological information, extract scale samples for ageing. Provide to NS DFA for science purposes
Atlantic Salmon – wild (adults and juveniles) *(Salmo salar)*	Count, sample and return to the river below the dam.	Record biological information, extract scale samples for ageing, collect a tissue sample (lower caudal punch) for possible later genetic assessments. Submit mortalities for fish health screening.
Atlantic Salmon - Aquaculture Escapee *(Salmo salar)*	Count, sacrifice or sample and return to below dam – see sampling considerations	If clearly obvious escapee (*i.e.*, broom tail, severe fin erosion, odd body shape), sacrifice the fish and send to fish health for disease screening. Any other fish of limited odd characteristics to be sampled as per wild Atlantic salmon

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[4] VIE: Visible Implant Elastomer is an internal coloured tag that is visible externally.

		considerations above and the envelope marked possible aquaculture escape and returned below the dam.
Brook Trout *(Salvelinus fontinalis)*	Count, sample and allow passage into Hebb Lake	Record biological information, extract scale samples for ageing and tissue samples for possible use in later genetic assessments, fin clip. If more than several (about 12) large specimens are captured in the trap (>25cm), consideration will be given to returning additional larger specimens to the river downstream of the dam. This direction will be provided within the season by DFO, as appropriate.
Rainbow Trout escapees *(Oncorhynchus mykiss)*	Count, sacrifice, provide to NS DFA for science purposes	No sampling requirements
Alewife *(Alosa pseudoharengus)*	Identify as alewife. Estimate numbers, sample and allow passage into Hebb Lake of 20,000 spawners (upper limit of 30,000 spawners)	Sampling to confirm the gaspereau are alewife. Otherwise no other sampling requirements. The sample rate and procedure will be provided to those conducting the monitoring by DFO Science and adjusted accordingly depending on the run size.
Blueback Herring *(Alosa aestivalis)*	Identify as blueback. Estimate numbers, sample and allow passage into Hebb Lake of numbers not to surpass total alewife recommendation for a total "gaspereau" count	Sampling to confirm that the gaspereau are alewife or blueback herring, otherwise no sampling requirements. The sample rate and procedure will be provided to those conducting the monitoring by DFO Science and adjusted

		accordingly depending on the run size.
American Shad (Alosa sapidissima)	Count, sample, and return to below the dam.	Record biological information
Sea Lamprey *(Petromyzon marinus)*	Count, sample and return to below dam	Record biological information
Others (*e.g.*, White Perch, Yellow Perch, White Sucker, Brown Bullhead, etc.)	Count, sample and allow passage into Hebb Lake.	Record biological information

5. Communication with the Recovery Team and implementation of revised interim monitoring protocols during the spring 2013 monitoring season.

   Results and Recommendations:
   - Results of monitoring in 2012 were presented in part by DFO Science and in part by BCAF at both the October 24, 2012 and February 5th 2013 recovery team meetings.
   - These revised protocols were reviewed by the Hebb Dam Fish Passage Working Group prior to finalization and distribution to the broader Recovery Team
   - The revised protocols were shared with the monitoring proponent (e.g., BCAF) for implementation during the 2013 monitoring season and given the go-ahead by the department to proceed with opening and operating the fishway and fish trap on May 10, 2013.

6. Monitoring of the extant wild population of Atlantic Whitefish within Hebb Lake should be undertaken prior to the fishway becoming operational to establish baselines for their general status and biological traits at the onset of entry of wild fish (e.g., alewife) returning from below Hebb Dam.

   Results:
   - A trap net was installed by DFO Science in Hebb Lake at the base of Milipsigate Dam in May 2012. The trapnet operated for a few weeks (May 6 – May 14, 2012). No Atlantic Whitefish were intercepted in the trap itself. Two individuals were observed swimming outside the trap in the area.

   Recommendations:

- Previous samples collected over the years of Atlantic Whitefish have provided baseline data on the fish size and condition factor. Ideally, the planned monitoring in Hebb Lake in 2013 would be expected to provide additional samples of Atlantic Whitefish to add to baseline information prior to alosine migration into the lake. Samples collected to establish that baseline indicate the biological condition of fish is similar to that reported by Edge and Gilhen (2001)[5]. Should sampling not be successful in 2013 in Hebb Lake, at least coincident with the alosine entry to the lake, the baseline sample information will be used for any future comparisons of Atlantic Whitefish condition. In addition, Atlantic Whitefish from Minamkeak or Milipsigate lakes could serve as sentinel populations for comparison at some future time, if thought necessary.

PHASE 3 – Long-term Monitoring Plan

The review of the results of Phases 1 and 2 is expected to provide information related to fish passage effectiveness and fish community characteristics. These results will be used to revise this document into a long term monitoring plan. This version of the plan will include the ongoing operational control protocols for the various species when they are expected to be at the facility (*i.e.* update table provided above).

It is anticipated that the long term monitoring plan will be adaptive to take into account information regarding the biology and recovery of the Atlantic Whitefish as obtained. Moreover, as additional fish passage facilities are constructed on the Petite Rivière and potentially elsewhere within the Atlantic Whitefish historical range this plan will be adapted to take these broader monitoring requirements into account. The plan will need to be adaptive to incorporate new research findings and annual changes in the presence of new species or abundance of certain species.

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[5] Edge, T.A. and J. Gilhen. 2001. Updated status report on the endangered Atlantic whitefish, Coregonus huntsmani. Canadian Field-Naturalist. 1115(4): 635-651.

Appendix 1.1

Atlantic Whitefish Hebb Dam Fish Passage Working Group

Terms of Reference
June 2011

Background

This working group was created in response to the current construction of the Hebb Dam fishway on the Petite Rivière by the Public Service Commission of Bridgewater (PSCB) and the need to develop a monitoring plan and operational control protocols related to fish passage into Hebb Lake by various native and non-native fish species including captive-reared origin Atlantic Whitefish.

Mandate

This working group assists DFO with the development and review of any plans for the monitoring and passage control of fish entering the Hebb Dam fishway. Particular consideration will be given to an evaluation of the potential risks/impacts and interactions associated with the introduction into Hebb Lake of identified native and non-native fish species. Operational protocols to control their passage are essential and will be in place to ensure species entering the lakes will not pose a risk to the lake populations of Atlantic Whitefish. The working group will discuss these protocols, funding options related to monitoring fish passage, the preferred trapping method and other areas of project support. The working group supports the concept that the fishway should become fully operational following its completion. A phased in approach will be put in place for the first year (2011) (see 'Interim Monitoring Plan' for details) with a longer term plan developed for implementation next fall. The working group provides information and recommendations to the Atlantic Whitefish Conservation and Recovery Team (AWCRT).

Objectives

The Objectives of the Working Group are to:

- Assist DFO with the development an interim monitoring plan and operational controls at the Hebb Dam fishway for fall 2011 – winter/spring 2012 needs.
- Assist DFO with the development of an adaptive long-term monitoring plan at the Hebb Dam fishway to assess the response of Atlantic Whitefish to an expanded geographic range.

- Ensure that a consistent and strategic approach is taken in decision-making with respect to operational controls of fish species in the monitoring plan, including captive-reared origin Atlantic Whitefish entering Hebb Lake.
- Provide a forum to discuss fish passage monitoring, control protocols, trapping options, funding options, science/research needs, reporting and community involvement at the Hebb Dam fishway.
- Ensure that knowledgeable experts have input into the development of any plans and actions relating to fish passage at the Hebb Dam fishway.
- Develop options and recommended courses of action for advice for other fish passage facilities on the Petite Rivière as constructed as well as advice on considerations of fish passage needs elsewhere within the species' historical range.

Roles and responsibilities

The responsibilities of the Working Group members are as outlined:

- Assist DFO in assembling the monitoring plans (interim and long term) and review any issues related to fish passage at Hebb Dam.
- Provide the Recovery Team with options and recommended courses of action, including direction on technical and scientific matters.
- Conduct the above tasks to support the Recovery Strategy related to the survival of Atlantic Whitefish and facilitation of anadromy on the Petite Rivière as per associated recovery measures outlined in the draft Action Plan.
- Review the potential risks related to the passage of identified native and non-native fish species into Hebb Lake including captive-reared origin Atlantic Whitefish and provide results of this review to the Recovery Team.
- Facilitate a working relationship with PSCB to ensure operations and maintenance of the fish passage structure is conducted within the objectives of the monitoring plan.
- DFO Communications to relay information on plans and actions related to fish passage on the Petite Rivière to the Communication Sub-Committee of the Recovery Team, who will then lead on all communication aspects of this project to the local community at large at appropriate stages.

Membership

The Chair of this working group will be the Chair of the Atlantic Whitefish Conservation and Recovery Team or an assigned delegate.

Members of the Working Group will be selected from the Recovery Team membership:

- DFO sectors: Science, Resource Management, Habitat Management, Species at Risk Management Division and Communications

- Town of Bridgewater Public Service Commission (PSCB); Nature Nova Scotia; Bluenose Coastal Action Foundation (BCAF); Native Council of Nova Scotia:
- Province: NS Department of Fisheries and Aquaculture
- Nova Scotia Power Incorporated (NSPI)
- Other experts: will be invited to participate as needed.

Meetings

In the summer of 2011 several meetings (including conference calls) will be required to review the interim monitoring plan. Once the fishway is operational and the trapping mechanism in place, meetings will typically be required prior to the opening of the fishway to discuss monitoring objectives, needs and operational protocols.

Appendix 1.2

Images of Hebb Lake Dam, conceptual sketches and images of the fish passage facility and fish trap

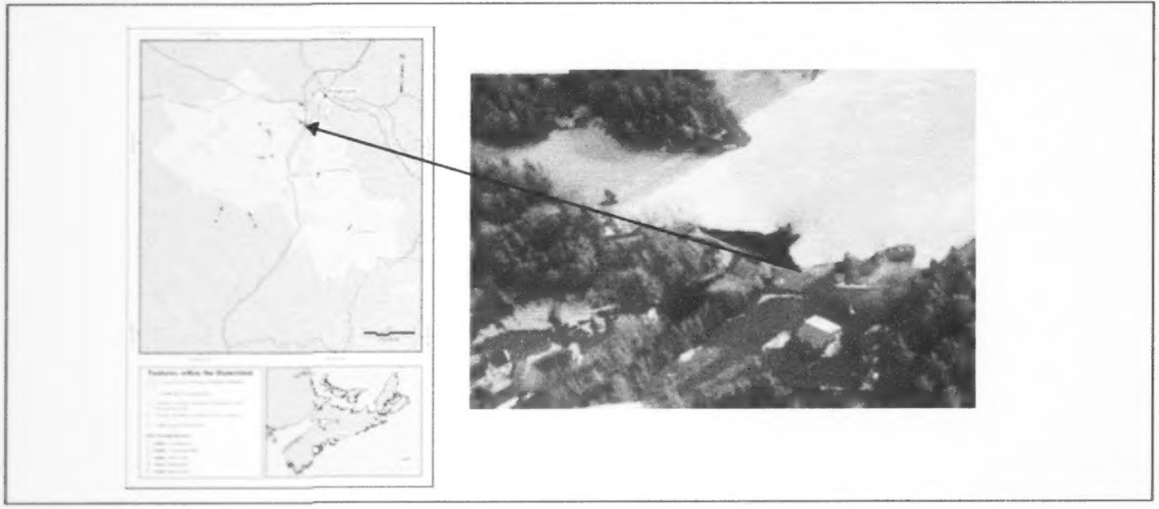

Figure 2: Location of Hebb Dam on the Petite Rivière

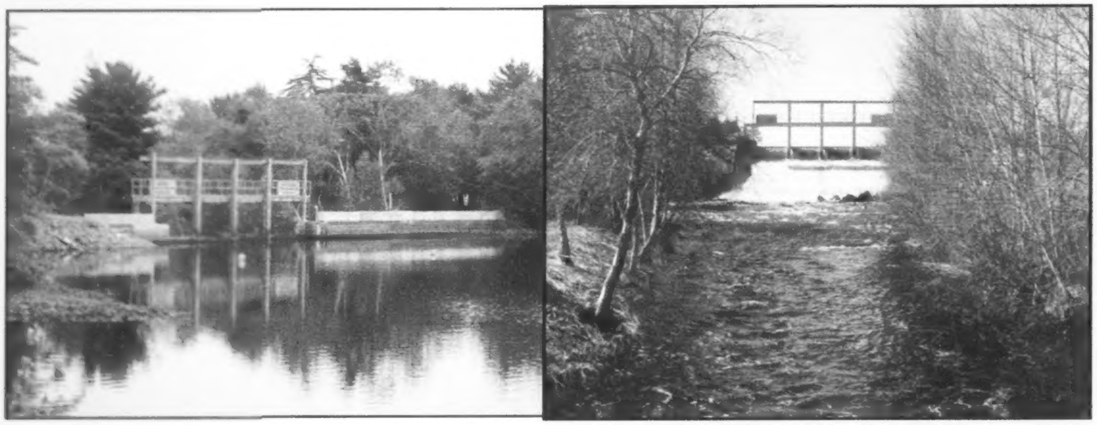

Figure 3: Hebb Dam upstream (upper image) and downstream (lower image) views

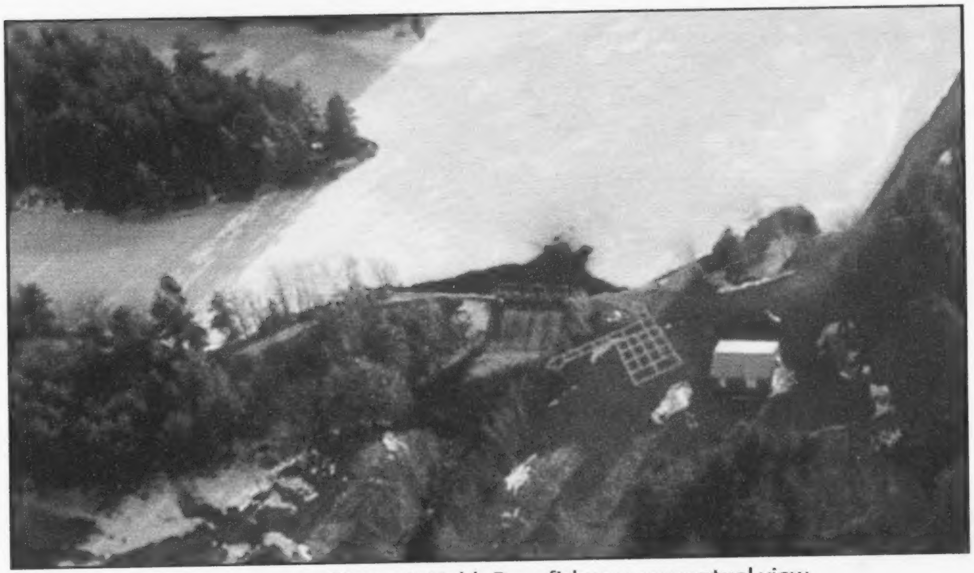

Figure 4: Hebb Dam fishway conceptual view

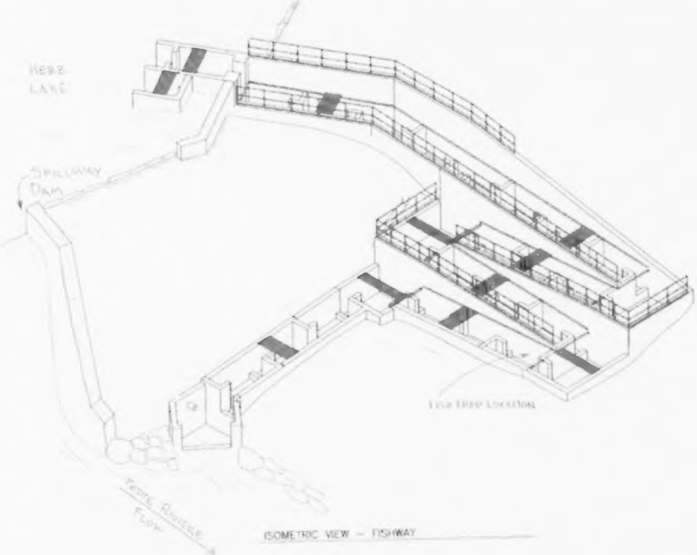
HEBB LAKE
SPILLWAY DAM
Fish Trap Location
PETITE RIVIERE FLOW
ISOMETRIC VIEW – FISHWAY

Figure 5: 3D sketch of the fishway showing the location of the fish trap in the lower pool

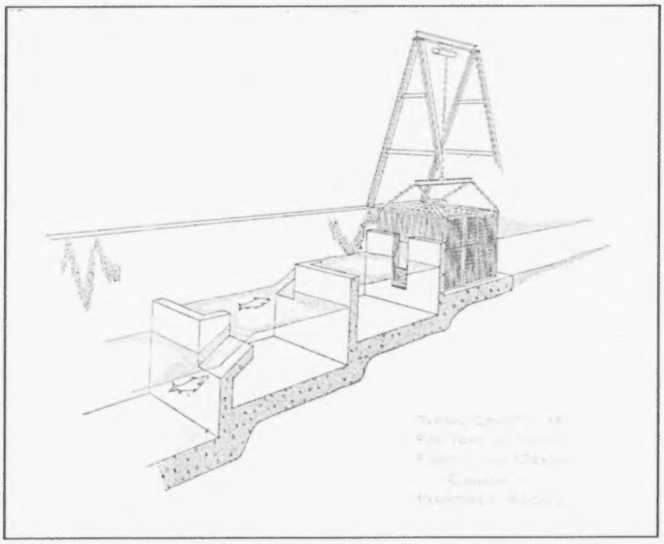

Figure 6: 3D sketch of a typical fish trap within a fishway

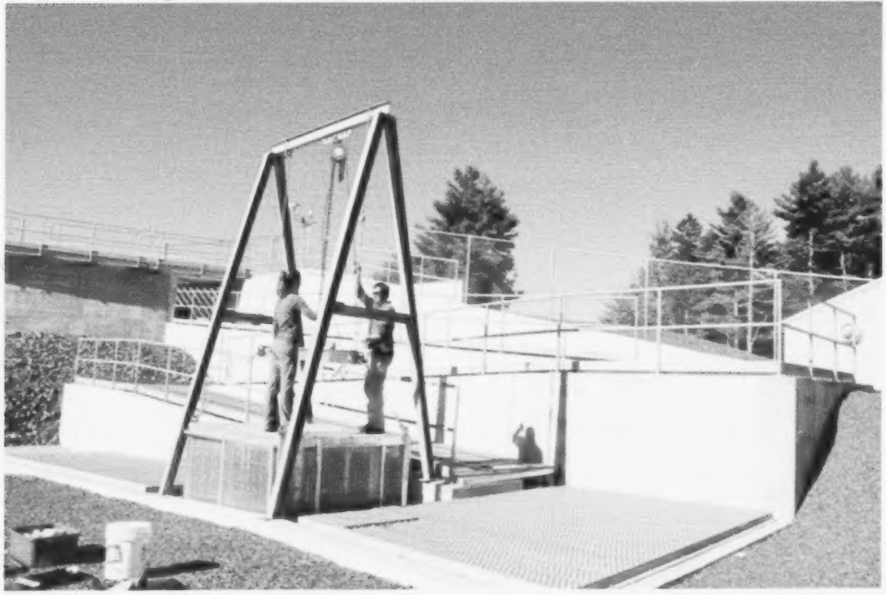

Figure 7: fish trap installed within the lower end of the fishway

APPENDIX 2. QUALITATIVE REVIEW OF THE RISKS OF PROVIDING FISH PASSAGE VIA A FISHWAY INTO HEBB LAKE, PETITE RIVIERE, NOVA SCOTIA: REVIEW OF THE RISKS OF PASSING DIADROMOUS FISH AND OTHER RIVER-RESIDENT FISH INTO THE RIVER ABOVE HEBB DAM

PREPARED BY FISHERIES AND OCEANS AS PART OF THE HEBB LAKE DAM FISH PASSAGE MONITORING PLAN ASSOCIATED WITH AN ACTION PLAN TO RECOVER ATLANTIC WHITEFISH

DATE: APRIL 2013

This qualitative risk review of fish passage at Hebb Dam and the risks to Atlantic whitefish is based generally on the National Code on Introductions and Transfers. The risk assessment process was adapted from the Fisheries and Oceans risk assessment framework for Science advice.

Table of contents:

Purpose of risk assessment: 63

B. Introduction 66

C. Life history information of species to be introduced or transferred 74

D. Interaction with native species 78

E. Precautions 81

F. Monitoring 83

G. Management Plan 83

H. Business plan / Other 84

I. References 85

J. Risk review process and results: 86

Purpose of risk assessment:

The population of Atlantic whitefish is globally endemic to Nova Scotia and the wild population limited to the Petite Rivière watershed. The extant reproducing population is believed to be limited to 3 lakes located in the headwaters of the Petite Rivière upstream of the dam located at the outflow of Hebb Lake on the system. Hebb Lake is the lowermost of the 3 lakes in the system where wild fish are believed to be reproducing. Those lakes are Milipsigate, Minamkeak, and Hebb. Fish passage was recently constructed to permit upstream and downstream passage of fish around the Hebb Lake Dam. There is a trap in the fishway that can be used to select which fish are passed upstream and the number of each species that are released into Hebb Lake. There are risks to permitting fish above the Hebb Lake Dam and this risk assessment is to qualify those risks and put them in perspective to guide the operation of fishway trap.

A draft protocol to guide passage of fish upstream of the dam at Hebb Lake was developed by the Fisheries and Oceans Species at Risk Office and the Atlantic Whitefish Conservation and Recovery Team. The following table from that document describes the management approach to fish passage as phase 1 in year one. Phase 2 is scheduled for subsequent years.

Table 1. Draft protocol to guide fish passage of fish upstream of the dam at Hebb Lake (from:

Species	**Protocol**	**Sampling Considerations**
Wild Atlantic Whitefish *(Coregonus hunstmani)*	Identify as wild, sample and allow passage into Hebb Lake	Identify as a wild fish if it does not possess the captive-reared markings described below. Apply an external mark, record biological information, extract scale samples for ageing and tissue samples for later genetic assessments
Captive-reared Atlantic Whitefish *(Coregonus hunstmani)*	Identify as captive-reared, sample and return to below dam	Identify as a captive-reared fish (adipose fin markings or a red or pink VIE[6] mark on the left pectoral), record biological information, extract scale samples for ageing and tissue samples for later genetic assessments, fin clip, subsample for fish health screening
American Eel *(Anguilla rostrata)*	Sample and allow passage into Hebb Lake	Record biological information, subsample for fish health screening
Smallmouth Bass *(Micropterus dolomieu)*	Sacrifice, provide to NS DFA for science purposes	Record biological information, extract scale samples for ageing and tissue samples for use in later genetic assessments, fin clip, subsample for fish

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[6] VIE: Visible Implant Elastomer is an internal coloured tag that is visible externally.

		health screening
Atlantic Salmon – wild (adults and juveniles) *(Salmo salar)*	Sample and return to below dam	Record biological information, extract scale samples for ageing, collect a tissue sample (lower caudal punch) for later genetic assessments. Submit mortalities for fish health screening.
Atlantic Salmon - Aquaculture Escapee *(Salmo salar)*	Sacrifice or sample and return to below dam – see sampling considerations	If clearly obvious escapee (*i.e.*, broom tail, severe fin erosion, odd body shape), sacrifice the fish and send to fish health for disease screening. Any other fish of limited odd characteristics to be sampled as per wild Atlantic salmon considerations above and the envelope marked possible aquaculture escape and returned below the dam.
Brook Trout (*Salvelinus fontinalis)*	Sample and return to below dam	Record biological information, extract scale samples for ageing and tissue samples for use in later genetic assessments, fin clip, sub-sample for fish health screening
Rainbow Trout escapees (*Oncorhynchus mykiss)*	Sacrifice, provide to NS DFA for science purposes	
Others (*e.g.*, White Perch, Yellow Perch, White Sucker, Brown Bullhead, shad, etc.)	Sample and return to below dam	Record biological information, subsample for fish health screening
Alewife (*Alosa*	Not expected to arrive before spring, protocols will be	

pseudoharengus)	established in Phase 2	
Blueback Herring *(Alosa aestivalis)*	Not expected to arrive before spring, protocols will be established in Phase 2	
Sea Lamprey *(Petromyzon marinus)*	Not expected to arrive before spring, protocols will be established in Phase 2	

Note that for 2013, acoustic tags may be inserted in some Atlantic whitefish captured in the trap. Also, one aspect of the monitoring work planned, as per the draft protocol, is to assess the feasibility of using the fish trap to manage fish passage effectively.

B. INTRODUCTION

1. Name (common and scientific) of the organisms proposed for introduction: Alewife *Alosa pseudoharengus*; blueback herring *Alosa aestivalis*; Shad *Alosa sapidissima*; American eel *Anguilla rostrata*; white perch *Morone americana*; Atlantic salmon *Salmo salar*, smallmouth bass *Micropterus dolomieu;* brooktrout *Salveliinas fontinalis*; and Atlantic whitefish *Coregonus huntsmani*. These are the fish species that are most likely to be encountered in the fishway (others could include white sucker, brown bullhead, yellow perch; sea lamprey, rainbow trout).

2. Describe the characteristics, including distinguishing characteristics of the organism.

Alewife (*Alosa pseudoharengus*): Alewife general biology and distribution is described in the Underwater World document that can be found at the following link: http://www.dfo-mpo.gc.ca/science/publications/uww-msm/articles/alewife-gaspareau-eng.htm; http://library.fws.gov/pubs5/web_link/text/int_fish.htm.

Alewife are reported to occur in most watersheds in the south shore, including the Petite Rivière.

Blueback herring (*Alosa aestivalis*): It isn't certain that blueback herring are present in the Petite Rivière, although alewife and blueback herring are both found in some watersheds in the region (see attached document and the link provided for Alewife)

Alewife and blueback
herring Saint John Riv

American shad (*Alosa sapidissima*): American shad populations are relatively limited on the Atlantic coast of Nova Scotia but shad have been observed in the Petite Rivière. Given the possibility that shad may enter the fishway and that a decision will have to be made about permitting them upstream of the Hebb Dam fishway, they are included here. General biology and distribution information can be found in the Underwater World document at the following site:

http://www.dfo-mpo.gc.ca/Science/publications/uww-msm/articles/shad-alose-eng.htm.

American eel (*Anguilla rostrata*): American eel are found throughout watersheds of Nova Scotia and are found in the Petite Rivière system. American eel can migrate upstream past partial or near full obstructions as juveniles so would be expected to be present above and below Hebb Lake Dam and to have had access prior to the fishway being constructed. It is not known if the yellow eel stage fish (post larval but pre-maturing stage) migrating upstream and found in the fishway would have a different pathogen or parasite load than eels that ascended into Hebb Lake and above as young migrants or larval fish (elvers). As a precaution, eels are included here to consider the risk of their passage upstream given that data are not available.

White perch (*Morone Americana*) : White perch are found upstream and downstream of Hebb Lake Dam on the Petite Rivière system. Some information on the biology and distribution of white perch can be found at the following link: http://www.gov.ns.ca/fish/sportfishing/species/wper.shtml.

Atlantic salmon (*Salmo salar*): Atlantic salmon are present in the Petite Rivière. Salmon populations are in serious decline on the Southern Upland of Nova Scotia, the area draining the coastland from Digby in the west to Canso in the east (http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2013/2013_009-eng.html). Atlantic salmon were encountered in the fishway trap in 2012 at Hebb Dam and the fish had external characteristics that were not typical of sea-run salmon from the Southern Upland. The preliminary protocol for operation of the trap stipulated that salmon be returned to the stream downstream of the fishway and not released into Hebb Lake. That will be the assumed operational approach so salmon are not dealt with otherwise in this document except in one other location (see).

Smallmouth bass (*Micropterus dolomieu*): An invasive species that was illegally introduced into the Petite Rivière system. Control measures for them are being considered and any fish captured in the fishway will not be released above the dam. A description of the biology and distribution of smallmouth bass is available in the following link: http://www.gov.ns.ca/fish/sportfishing/species/smb.shtml

Brook trout (*Salvelinus fontinalis*): A brief summary of the biological characteristics and distribution of brook trout in Nova Scotia has been prepared by the province and can be found at the following link: http://www.gov.ns.ca/fish/sportfishing/species/spec.shtml. Fisheries and Oceans has also prepared a similar summary for brook trout in Atlantic Canada which can be found at the following link: www.dfo-mpo.gc.ca/science/publications/.../**trout**-truites-eng.htm (Caution...the link for the DFO sites although working in mid April 2013 was down as of April 28, 2013). In summary, brook trout are resident throughout Nova Scotia and live in the Petite Rivière above and below Hebb Dam. They have co-existed with the Atlantic whitefish in the Petite since prior to the reservoirs being created in the early 1900s.

Sea lamprey (*Petromyzon marinus*): Sea lamprey are anadromous and enter streams and rivers from the ocean in the early summer to spawn in flowing areas of the river. A summary of the distribution and biology of sea lamprey is available in Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin 184. Fisheries Research Board of Canada. Ottawa, Canada. Migrating fish do not feed so are a limited risk to river-resident fish. Young may attach to river-resident fish briefly before migrating to sea but it is unlikely they are using the fish as a host prior to entering the lowermost reaches of the river or estuary. Sea lamprey have been reported in the neighbouring LaHave River so could be assumed to be present in the Petite Rivière.

Atlantic whitefish (*Coregonus huntsmani)*: The Atlantic whitefish is a salmonid that belongs to the whitefish subfamily Coregoninae. It appears salmon-like, with silvery sides, a silvery white underbelly, an adipose fin, deeply forked tail, and a back that is black, dark green or blue. Dorsal and caudal fins are dusky, lower fins are light. Nuptial tubercles or pearl organs are developed on males at least, on scales on flanks and also on top (few) and sides of head. Anadromous Atlantic whitefish adults typically average 38 cm in length while the smaller landlocked individuals range 20-25 cm. Species is readily distinguishable from most other salmonids by its larger scales. The Atlantic whitefish differ from the lake whitefish (*Coregonus clupeaformis*) in a number of characters, but especially the terminal mouth, the small scales, and the presence of small but well-developed teeth on premaxillaries, palantines, and vomer. More detailed information can be found in the Recovery Strategy for the Atlantic Whitefish (*Coregonus huntsmani*) in Canada[7]. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa, xiii + 42 pp.

Atlantic whitefish are present above and below Hebb Lake Dam but the fish below the dam are thought to be fish which have dropped downstream from the lakes[8].

3. Describe the history in aquaculture, enhancement, or other introductions.

Alewife, blueback herring, shad, white perch: No aquaculture or stocking history in Nova Scotia;

American eel: American eel are harvested for use in fish culture elsewhere but not in Nova Scotia. There is no American eel enhancement occurring in Nova Scotia.

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[7] Department of Fisheries and Oceans 2006. Recovery Strategy for the Atlantic Whitefish (*Coregonus huntsmani*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa, xiii + 42 pp.

[8] Bradford, R.G., P. Bentzen, D.M. Campbell, A.M. Cook, A.J.F. Gibson, and J. Whitelaw. 2009 Update Status Report for Atlantic Whitefish (Coregonus huntsmani).. DFO Sci. Adv. Sec. Res. Doc. 2010/005.

Smallmouth bass: Smallmouth bass have been stocked but are not grown in aquaculture. Historically some sites were stocked as part of government managed introductions and a single site recently in a quarry near Hantsport. However, there have been wide-spread illegal introductions in the Province including to the Petite Rivière[9]. A population of smallmouth bass is now established throughout the watershed.

Atlantic whitefish: Atlantic whitefish have not been stocked nor are they grown for aquaculture. However, lake whitefish (*Coregonus clupeaformis*) were stocked extensively throughout Nova Scotia but are not known to be present in the Petite Rivière.

Rainbow trout: Rainbow trout are grown in aquaculture in NS and have been stocked. There is only one site in southern NS that has been stocked and it is somewhat distant from the Petite Rivière, on a tributary to the Medway River.

Brook trout: Brook trout have been stocked throughout the Province into watersheds and trout ponds and have been released into the Petite Rivière for enhancement purposes by the Province. Brook trout are grown in trout ponds at various locations in the Province but they are not grown in sea-pen based aquaculture.

Other species: Other species such as yellow perch, brown bullhead, sea lamprey or white sucker, are not cultivated in Nova Scotia or stocked for enhancement.

4. What is the geographic area of the proposed introduction?

Hebb Lake is in the Petite Rivière watershed (44°20'45" North and 64°33'50" West; Figure 1). Three lakes on the Petite Rivière system, Milipsigate, Minamkeak, and Hebb, are located upstream of the dam at the mouth of Hebb Lake where the fishway is located. Fish passing through the fishway could potentially access the three lakes but fish passage is not present during average flows between all lakes because of a dam at the mouth of the Milipsigate Lake.

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[9] Bradford, R., H. Schaefer and G. Stevens. 2004.Scope for human induced mortality in the context of Atlantic whitefish (*Coregonus huntsmani*) survival and recovery. DFO Sci. Adv. Sec. Res. Doc. 2004/110.

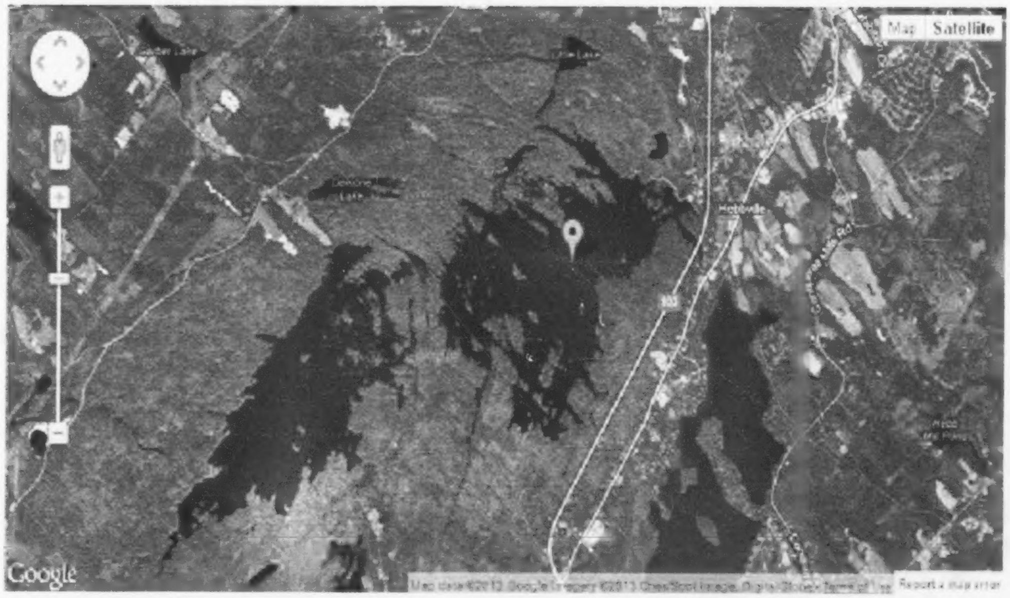

Figure 1. Hebb Lake (with red marker). Image copied from Google maps.

Impeded and ineffective fish passage between the sea and the lakes in Petite Rivière has been identified as a possible factor in the decline of the anadromous population in the area. Fish passage is obstructed or ineffective in five locations on the Petite Rivière between the uppermost lake, Minamkeak Lake, and the ocean: Crousetown dam, Conquerall Mills, Hebb Lake dam, Milipsigate dam and Minamkeak dam (Figure 2). The unauthorized introduction and subsequent spread of exotic invasive fish in the watershed, such as smallmouth bass, may also pose a significant threat to the survival of the last remaining population. A more comprehensive discussion of known and potential threats is provided in the recovery strategy (see footnote 2).

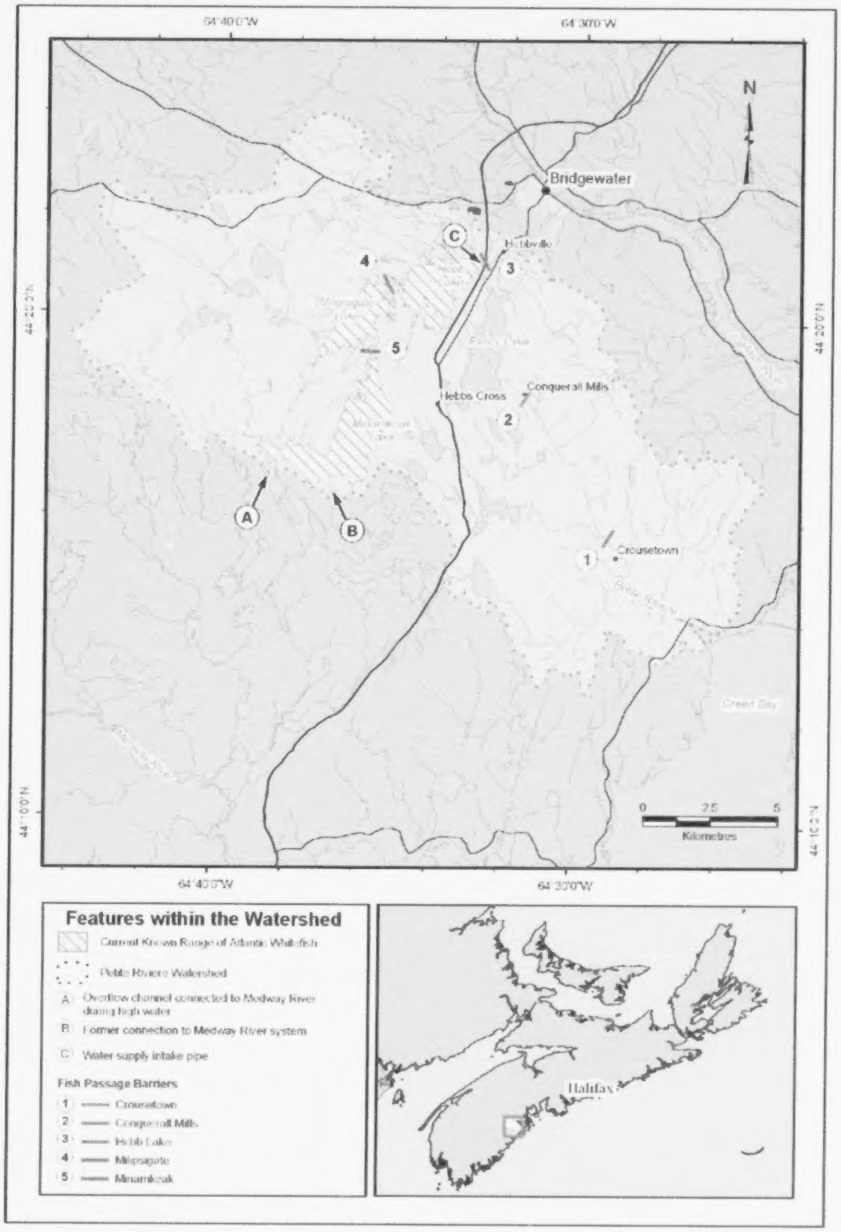
64°40'0"W
64°30'0"W
44°20'0"N
44°10'0"N
N
Bridgewater
Hebbville
Hebbs Cross
Conquerall Mills
Crousetown
A
B
C
1
2
3
4
5
0
2.5
5
Kilometres
Halifax
Features within the Watershed
Current Known Range of Atlantic Whitefish
Petite Riviere Watershed
A Overflow channel connected to Medway River during high water
B Former connection to Medway River system
C Water supply intake pipe
Fish Passage Barriers
1 Crousetown
2 Conquerall Mills
3 Hebb Lake
4 Milipsigate
5 Minamkeak

Figure 2. Petite Rivière watershed showing location of lakes and fish passage barriers (map copied from the Recovery strategy, see footnote 5)

5. What alternative strategies have been considered in order to meet the objectives of the proposal? What are the implications of a "do nothing" option?

Re-establishing the anadromous habit for Atlantic whitefish is consistent with the Recovery Strategy for Atlantic Whitefish in Canada[10] and the DRAFT Action Plan[11] . Operation of the fishway is being guided by a "living" monitoring plan[12] that has been completed but will be updated as appropriate. The fishway is now operational.

The Atlantic Whitefish Conservation and Recovery Team considered a few options to limit the risk of extinction of the species and to provide recommendations to Fisheries and Oceans. The "do nothing" option was not considered a viable option once the illegal introduction of smallmouth bass to the Petite Rivière, including the lakes where the last population of Atlantic whitefish was known to occur, had taken place.

6. Describe the objectives, rationale, economic, biological, and sociological impacts of the proposed introduction, including an explanation as to why such an objective cannot be met through the utilization of an indigenous species.

The rationale has been explained in the objective above. The biological impacts are dealt with throughout this assessment document. The primary risk to the extant whitefish population is the ecological impact that may occur with a species such as alewife that could have a potential benefit but also pose a risk. Alewife would be expected to provide a food supply both as gametes and larvae for Atlantic whitefish while at the same time, the adult may prey on juvenile Atlantic whitefish post spawning. Adult alewives feed little during their spawning migration (see link in section B.2). Juvenile Atlantic whitefish are expected to be sufficiently large by the time juvenile alewives are large enough to prey upon larval sized fish to be excluded from the prey field. The ecological impacts of alewife in the lakes is paradoxical as the contribution of a food source for the whitefish could also be a contribution of a food source for smallmouth bass, an invasive that could have an impact on whitefish populations. Anything which promotes the growth or expansion of the smallmouth bass population could negatively impact Atlantic whitefish.

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[10] Department of Fisheries and Oceans 2006. Recovery Strategy for the Atlantic Whitefish (*Coregonus huntsmani*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa, xiii + 42 pp.

11 Fisheries and Oceans Canada. 2012. Action Plan for the Atlantic Whitefish (Coregonus huntsmani) in Canada [Draft]. Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa.

[12] DRAFT- Maritimes Region Species at Risk Office. Hebb Lake Dam Fish Passage Facility Interim Monitoring Plan Update: Results of Fall 2012 Monitoring and Recommendations for Spring – Fall 2013.

An important aspect of this risk review is determining the relative risk of benefiting the smallmouth bass population against benefiting the Atlantic whitefish population. There are plans to explore controlling the smallmouth bass population. It is also very likely that the presence of alewife will provide an alternative prey source for smallmouth bass and reduce the impact on Atlantic whitefish through predation.

The sociological and economic impacts are minimal because this is a well vetted step in an attempt to maintain and contribute to recovery for the endangered Atlantic whitefish. Indigenous species are all that are involved here so the non-indigenous species concern is not applicable.

Previous steps in the Species at Risk review process have dealt with allowable harm and impacts on local land uses.

7. Describe the numbers of fish proposed for the introduction (initially, ultimately). Can the project be broken down into different sub components; if so, how many fish are involved with the different subcomponents?

Options exist here.

As per the Hebb Lake Dam fish passage facility interim monitoring plan (see footnote 7): "A phased and precautionary approach to fish passage is being conducted, with the interim monitoring plan (goals and operational controls) initially focused on allowing wild Atlantic Whitefish to return to Hebb Lake (Phase 1)."

A recommendation was made to the Atlantic Whitefish Conservation and Recovery Team to permit 20,000 alewife into Hebb Lake. This is about 2% of the estimated maximum carrying capacity for the lake of about 950,000 spawners. It was noted in the recommendation that a maximum of 30,000 would be permitted should large numbers arrive at the fishway. This is well below the carrying capacity of the lake but precautionary.

Brook trout: Based on previous operational protocol discussions (see footnote 7) brook trout that are captured in the trap were to be treated as low risk and put upstream. This document (risk review) poses the option of selecting which brook trout are put upstream (See section J). It is possible that some brook trout that come to the fishway are from those stocked by the Province of Nova Scotia. Survival of stocked fish is not expected to be as high as for wild fish but the relative risk either form may pose to the resident whitefish population is not known (Alexander 1973).

8. Describe the source(s) of the stock (facility/genetic stock, if known).

The fish that will be passed upstream of the dam are from the native river stocks with a couple of provisos. It has already been decided that any fish that appeared to be of aquaculture origins would not be passed above the dam, for example any rainbow trout or Atlantic salmon of farm-origins. Smallmouth bass are not native to the Petite Rivière so will be removed and sacrificed. On previous occasions, as part of the population maintenance and recovery processes, cultured Atlantic whitefish were released into the Petite Rivière below Hebb Dam. If those fish arrive at the fishway, they will be given special consideration and may not be released upstream. Atlantic whitefish that appear to be from the wild population will be released upstream of the dam. Brook trout are stocked into the Petite Rivière by the Province of Nova Scotia. Those fish are screened by the Regional Fish Health office prior to release. It is difficult to tell those cultured fish from wild brook trout so all trout found in the fishway trap will be passed above the dam, subject to an option to selectively release trout based on size that is posed in the Section J risk assessment table (Table 2).

C. LIFE HISTORY INFORMATION OF SPECIES TO BE INTRODUCED OR TRANSFERRED

1. Describe the natural range and present (introduced) range.

Any fish released above Hebb Dam into the lakes above would be fish from the Petite Rivière. The lakes upstream of the dam have been described by others (Edge and Gilhen 2001).

2. Describe the physiological tolerances at each life history stage (spawning, young-of-year, juveniles, and adults).

This is not relevant to the current review as all species are river resident.

3. Describe the habitat requirements for each life history stage.

For those species expected to be encountered in the trap that would be considered relatively low risk to put upstream of the dam, most would be well- to reasonably well-suited to the habitat of one or more of the lakes that could be accessed. Those include alewife, blueback herring, American eel, brook trout and white perch. Some habitat information would be provided for those species in the links pointed out in section B.2 above. Alewife that are released upstream of Hebb Dam would only have access to Hebb Lake so would not overlap in habitat with Atlantic whitefish in either Minamkeak or Milipsigate lakes.

Little is known of the habitat requirements of Atlantic whitefish. Spawning, nursery, and rearing ground locations and preferences are not known, and migration areas are not understood. In the Petite landlocked population, adults appear to prefer surface waters compared to mid-water or bottom habitats, and appear to tolerate relatively warm water conditions in comparison to lake whitefish (Edge and Gilhen 2001). Adults have the ability to tolerate full (31 ppt) seawater. The presence and persistence of the species in the 3 lakes in the Petite Rivière confirms that the habitat in those water bodies is suitable for growth and reproduction of the species.

4. Describe the reproductive biology.

Alewife spawn in lakes in May and June; blueback herring at similar times but tend to use pools and flats or stills in rivers. Refer to the links noted above for more information. Alewife eggs are broadcast in the lake over shallows or into the mid-depth waters but are demersal and eventually sink to adhere loosely to the substrate (see link in B.2).

Brook trout spawn in autumn, typically in October and November, some in flowing areas of streams and rivers while others may spawn in up-welling areas of lakes. The spawning involves creation of a redd or in-gravel nest in the stream bottom (or lake as the case may be). Incubation occurs through the winter months and newly hatched fish or alevins emerge from the redds typically in April/May after they have absorbed the majority of their yolk sac, where in streams, the current disperses the young in a somewhat contagious distribution downstream of the redd location. The juvenile trout or fry then begin to more actively search out a location to establish as their station. They remain in that location for the first few weeks of growth. Some trout in streams may be dispersed downstream into a lake, if present[13]. There could be some limited overlap of young-of-the year trout and Atlantic whitefish habitat. However, the two species have co-habited in the Petite lakes for decades so any overlap would not be considered a threat or high risk to the Atlantic whitefish.

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[13] Curry, R.A. 2005. Assessing the reproductive contributions of sympatric anadromous and freshwater-resident brook trout. J. Fish Biol. 66:741-757.

Johnson, J.H. 2008. Seasonal habitat use of brook trout and juvenile Atlantic salmon in a Tributary of Lake Ontario. Northeastern Naturalist, 15: 363 – 374.

Curry, R.A., C.Brady, D.L.G. Noakes, and R.G. Danzmann. 1997. Use of Small Streams by Young Brook Trout Spawned in a Lake. Trans. Amer. Fish. Soc. 126:77-83.

Little is known of the reproductive biology of Atlantic whitefish. Specimens captured in October and November had well developed gonads but had not yet spawned, while specimens collected in May and June had poorly developed gonads, suggesting spawning had occurred[14]. Animals held in captivity matured in December and, depending on the year, spawned early or late in December.

American eel: spawning occurs at sea so is not included here. Mature or nearly mature eels migrate downstream to the ocean in autumn.

Smallmouth bass: The protocol that was developed for the fishway prior to this risk review being completed already directed that smallmouth bass would not be put above the dam so a description of the spawning behaviour is not relevant to this review. However, it is important to note that during spawning, males guard the nests against predation and any control measures put in place to affect population size is likely to take advantage of that behaviour.

Sea lamprey: Sea lamprey ascend rivers and streams in early summer to spawn in moving water. Their reproductive behaviour is relevant here because young lamprey (ammocetes) could attach to Atlantic whitefish. Also, the presence of lamprey upstream of Hebb Dam may serve as an attractant to other lamprey, heightening any risk should they pose a threat.

Other species such as perch: Because the species have co-existed since the reservoirs were created, the reproductive biology is not considered relevant to this risk review.

5. Describe the migratory behaviour.

Migratory times for relevant species are noted in the links provided above in B.2. Some are primarily seasonal migrants such as alewife, which ascend the river in May and June as adults and descend shortly afterwards. Juvenile alewives migrate downstream from August through October depending on the year and this may vary within this period by population. Some species are known to have sporadic movements during the year such as white perch, brook trout and American eel, although both brook trout and eel have seasonal migrations depending on their state of maturity.

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[14] Bradford, R., D.L. Longard, and P. Longue. 2004a. Status, trends, and recovery considerations in support of an allowable harm assessment for Atlantic whitefish (*Coregonus huntsmani*). DFO Can. Sci. Advis. Sec. Res. Doc. 2004/109.

Atlantic whitefish: Spawning of the landlocked population in the Petite Rivière lakes probably occurs in December based on observed instances where fish have been captive reared and the observations by Edge and Gilhen (2001) on the anadromous form that was found in the Tusket River.

6. Describe the food preferences for each life history stage.

Alewife: Spawning adults do not eat much if at all; juveniles eat predominately plankton, insects, or larval fish until they reach a size of several cms when they could prey on minnows. Atlantic whitefish juveniles would be expected to be large enough by the time juvenile alewife would be preying on minnow-sized fish to be outside the prey range. It is not known if post-spawned adult alewife would prey on juvenile whitefish but it is likely. The incidence is not known.

Blueback herring: Similar to alewife.

Brook trout: Brook trout are essentially omnivores but certainly piscivorous and would be expected to prey on various life stages of Atlantic whitefish depending on relative size.

Atlantic whitefish: To date, no larvae or young of the year have been observed in the wild. A single land-locked juvenile was captured in 2000 on the Petite Rivière system. Adults feed on a wide variety of aquatic organisms, with some apparent differences in preferences between Tusket and Petite and landlocked and anadromous populations. Aquatic insects and zooplankton predominated in diets of landlocked specimens. The lack of benthic organisms observed in stomach analysis supports the view that the landlocked Petite Rivière population prefers surface waters over those at depth where benthic organisms would be expected to comprise more of the diet. Although the freshwater resident form is the only one under consideration here, with the opening of the fishway, anadromy could well become a common trait. Marine specimens of Atlantic whitefish were found to contain shrimp, amphipods, fish and marine worms[15].

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[15] Edge, T.A. and J. Gilhen. 2001. Updated status report on the endangered Atlantic whitefish, *Coregonus huntsmani*. Canadian Field-Naturalist. 1115(4): 635-651.

7. Describe the growth rate and life span (also in the area of the proposed introduction, if known).

Provided for Atlantic whitefish only: Maturing Atlantic whitefish captured in the Petite in late summer and fall were believed to be three years of age. Age determination from scales has not been confirmed and is still being tested. Specimens believed to be three years old were approximately 30 cm in length. Captive animals reach a length of 12 cm in one year. Specimens that were 50cm in length were reported by Edge and Gilhen (2001) and others (c.f., Edge and Gilhen 2001).

8. Describe the known endemic pathogens and parasites of the proposed introduction if known.

Fish health screening for disease is being conducted as a risk mitigation approach. Details are provided in section E.2. below.

With respect to Atlantic whitefish, disease testing of captive and wild caught animals has been negative for standard Fish Health Protection Regulations disease agents. Examination of mortalities for parasites and pathology detected *Aeromonas hydrophila* in several specimens that were captured in 2001 and transferred to the Mersey Biodiversity Facility where they died a short time later due to scale loss and handling injury. All other specimens taken from the hatchery or captured from the wild, including 5 animals that were blood sampled in 2001, were found to be negative for disease and parasites. The presence of *Aeromonas hydrophila* was probably due to secondary infection by this opportunistic bacteria which is ubiquitous in freshwaters. There are no other known pathogens in the extant wild population and there hasn't been any evidence of the *Aeromonas hydrophila* in the 90+ specimens examined since that early group in 2001. There are no known surveys of parasites of the fish in the Petite Rivière.

D. INTERACTION WITH NATIVE SPECIES

1. What is the potential for survival and establishment of the non-native species following unintentional or unauthorized liberation?

Not applicable or necessary for this review for species other than alewife. Access to Hebb Lake may result in an increase in the population of alewife in the Petite Rivière. This may present a challenge to manage in future years because of the plan to limit escapement (B.7). Monitoring, if it occurs, will permit assessment of status over time.

2. What habitat(s) will the proposed species likely occupy in the proposed area of introduction, and will this overlap with any native species - especially those which are

vulnerable, threatened, or endangered species? (N.B. the >proposed area of the introduction= includes all contiguous waters).

Little is known of the habitat requirements of Atlantic whitefish. Spawning, nursery, and rearing ground locations and preferences are not known, and migration areas are not understood. In the Petite population, adults appear to prefer surface waters compared to mid-water or bottom habitats, and appear to tolerate relatively warm water conditions in comparison to lake whitefish. In the Tusket population, adults were frequently caught in the estuary. Adults have the ability to tolerate full seawater. Atlantic and lake whitefish co-exist with brook trout where both are present.

Species that would be expected to interact or overlap include alewife and brook trout. There would likely be limited overlap with blueback herring should they occur in the system. Alewives that are passed into Hebb Lake would not have access to Milipsigate or Minamkeak lakes because of fish passage barriers, unless an exceptional flood occurred. The fact that the fish will be limited to Hebb Lake (alewife) will permit an understanding of potential ecological impact without compromising the ecology of the other lakes. Selective fish passage, as is planned at the fishway, if monitoring is still in place, can also be used to exclude alewife in the future should a negative impact be evident.

3. What species presently occupy the niche the proposed species will fill? Are there any vacant niches that the proposed species could fill?

The one species that is proposed for entry into the lake that could alter the ecosystem in the lake is alewife. Information provided elsewhere in this risk assessment covers the primary concerns regarding the potential for the species to impact the ecosystem. For this risk review, the concern is if the benefit outweighs the risk. The risk factors are considered in Section J below. It is pertinent to note that the ecosystem in the Petite Rivière lakes (Hebb, Milipsigate, and Minamkeak) could be undergoing a major shift currently due to the illegal introduction of smallmouth bass. It is expected that smallmouth bass are impacting the food supply for Atlantic whitefish and that has to be taken into account when considering the risk benefit.

4. What types and amounts of forage are available for the proposed species at all stages of its development?

The forage base in the Petite lakes is not well known but there are species records for fish captured in the lakes in the past (see for example Edge 1984). The primary forage base for alewife will be plankton and insects for the young. The abundance or distribution of such forage in the lake is not known.

With respect to Atlantic whitefish: They are believed to feed principally on aquatic invertebrates. (Edge and Gilhen 2001). Stomach contents of adult specimens contained aquatic arthropods (mostly cladocera) and aquatic insects. Although only 28 specimens were examined, fish was found as a prey item only in specimens from a single lake on the Petite and accounted for 2.7% of the stomach contents. This result is probably influenced by the time the sample was taken and the small sample size. Nevertheless, the adult specimens examined from the Petite would suggest they would prey principally on aquatic insects and zooplankton. There is little known about juvenile whitefish diets but would presumably include invertebrates as a principle prey item. Larval whitefish reared in captivity are fed artemia and exhibit better growth and survival relative to those fed dry diets.

5. What are the likely effects of predation on and by the proposed species at all life history stages?

Unknown but a description of prey preferences has been provided elsewhere in this review for alewife. Atlantic whitefish are known to coexist with white perch, brook trout, white suckers and various cyprinids, American eel, and historically with gaspereau as well. Atlantic whitefish would be expected to prey principally on insects and zooplankton, based on stomach content analysis from specimens from the Petite Rivière (Edge and Gilhen 2001).

Smallmouth bass are believed to prey on juvenile Atlantic whitefish and are considered a threat. An approach to control the smallmouth bass population is being considered. Smallmouth bass caught in the fishway trap will not be released above the dam.

6. What is the potential for competition for space and food at all life history stages with other species in the new environment?

There will be species overlap between Atlantic whitefish and alewife. The consequences of that overlap are not believed to be of concern because of historical evidence that whitefish co-existed with alewife (e.g., in the Tusket River), and the fact that spawning alewife do not eat or their feeding is very limited. Passing alewife upstream of Hebb Dam will permit them access to Hebb Lake, not the other two lakes, Minamkeak and Milipsigate, so habitat overlap would be limited.

7. Will the new species survive and successfully reproduce in the target water body or will maintenance stocking be required?

Not applicable to this risk review.

8. Describe any possible direct (hybridization) or indirect (extirpation of local stocks) genetic impacts of the proposed introduction on native species.

Atlantic whitefish are a native species that have persisted in the Petite Rivière headwater lakes since the reservoir's were established. There are no known species in the system that are known to hybridize with whitefish. The other Nova Scotia population that is now believed extirpated from the Tusket River was possibly affected by the illegal introduction of invasive species such as chain pickerel and smallmouth bass. Chain pickerel is not present in the Petite Rivière system and there is consideration of putting controls in place for smallmouth bass. The protocol agreement established in 2012 precluded the release of smallmouth bass into the area above Hebb Dam.

9. Describe the potential impacts on the habitat alteration and water quality as a result of the proposed introduction.

No foreseeable impact to water quality is anticipated by releasing fish species above the dam. The reservoirs in the Petite Rivière serve as the water supply for the town of Bridgewater, Nova Scotia. This risk review has not considered the effect any water level changes may have on the lake(s) as a result of water use by the town of Bridgewater.

10. What are the likely effects of parasites and diseases on native stocks?

None expected. The disease screening of brook trout are meant to serve as a sentinel species for disease agents of record (see E.2).

11. Has the species been introduced elsewhere, and if so what have been the observed impacts, both positive and negative?

This is not an "introduction" and all species are river resident so this is not applicable.

E. PRECAUTIONS

1. What is the health status of the proposed species?

Fish health screening is being done on brook trout as a sentinel species to limit the risk of introduction of parasites or disease pathogens. Any obvious unhealthy fish will be removed from the fishway trap and not released upstream.

2. What precautions are being taken to ensure that the organisms are not harbouring any communicable pathogens or parasites?

It was decided that risk of disease organism transfer would be managed in a precautionary manner. Consultation would occur with the Regional Fish Health office to guide the approach and as a result trout were collected above and below Hebb Lake Dam as resident species to serve as the species of record for screening for any pathogens of concern.

Brook trout were collected above and below Hebb Dam to submit to the Regional Fish Health office in 2012 where they were examined for pathogens that are screened under the Regional Fish Health Protection Guidelines (RFHP). Those pathogens are: causative agents of Furunculosis and Enteric Redmouth Diseases, and Bacterial Kidney Disease (i.e. lesions caused by *Renibacterium salmoninarum*). In addition, virology was tested for infectious pancreatic necrosis (IPN) and infectious salmon anaemia. Brook trout were again collected in 2013 from above and below Hebb Dam for screening according to RFHP pathogens. Numerous Atlantic whitefish specimens have been examined previously and disease agents of concern were not found (see section C.8)..

Sampling of brook trout was considered suitable for screening for disease risks that might be associated with white sucker, alewife or blueback herring, according to the Regional Fish Health office[16]. The test results from 2012 indicated no fish pathogens of concern were present. IPN was found in the trout collected downstream of the dam but as this virus is found throughout trout populations in the Maritime Provinces it was not considered a disease agent of concern[17].

American eel in some locations in Nova Scotia have recently been found to carry a swim-bladder parasite which is not native to Nova Scotia. The incidence of this on the Petite Rivière is not known but it is also not possible to preclude eel from the area above the dam as they can migrate through the fishway as young eels without any ability to prevent their movement.

3. What chemical, biophysical, and management precautions are being taken to prevent accidental escape of any fish, parasites, and/or pathogens, and establishment in non-target recipient ecosystem?

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[16] Email summary of dialogue with the Regional Fish Health office.

[17]

Regular operation of the trap in the fishway will be used to selectively pass certain species of fish. It is possible that the bar spacing in the fishway trap may permit some species to pass regardless of any attempt to prevent their entrance into the lake above the dam (e.g., juveniles that are small enough to pass through the fishway bars[18]). Monitoring will help determine the likelihood and frequency of such instances. If it appears to be a problem of concern, it will have to be reviewed to see if alternate management can further limit the likelihood.

4. Detail contingency plans to be followed in the event of an unintentional, accidental, or unauthorized liberation of the species from the rearing and hatchery facilities or an accidental or unexpected expansion of the range.

There are currently no plans to effect or attempt a recapture of a fish that accidentally is released into Hebb Lake. Monitoring would be expected to detect an accidental release of large numbers of a species that could be expected to have a harmful effect on the Atlantic whitefish and should such an event occur, a review of the incident and best course of action will be determined.

F. MONITORING

1. Describe the plans for follow-up assessments of the proposed introduced species success in meeting/breaking the assessed risks of negative impacts on native species and their habitats.

The Department of Fisheries and Oceans will participate in the monitoring of the fishway trap, either directly or via contract in 2013. Longer term plans have not been made at this time. Plans for some limited monitoring in Hebb Lake in at least 2013 will be integrated into tracking the effects of the fishway opening. For example, there are current plans to capture some Atlantic whitefish in Hebb Lake to determine their condition factor for later comparison with fish captured after alewife have been released into Hebb Lake.

G. MANAGEMENT PLAN

1. Describe the management plan for the proposed introduction. This should include but not be restricted to the following information.

a) Disease status certification.

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[18] The fishway bars are ½" (1.3cm) diameter aluminium rods spaced at 1 ¼" (3.2cm) center-to-center; clear spacing in between the rods is ¾" (1.9cm).

As noted in E.2. above, fish health screening of brook trout will occur to serve as a sentinel species for limiting the risk of any disease or pathogen transfer.

b) How will the species be reared?

Not applicable.

c) Who will be permitted to use the proposed species and under what terms and conditions?

This is not relevant to this review. However, given that Atlantic whitefish are endangered and recreational fishing is still permitted in the lakes where the species is present, anglers may pursue those other species that are released upstream of the dam including brook trout and white perch. Any Atlantic whitefish released are not for recreational use or for harvest. The Nova Scotia Department of Aquaculture and Fisheries has adjusted the recreational angling season on the 3 lakes above Hebb Dam to limit the chance of hooking an Atlantic whitefish.

d) Will there be a pre-commercial phase for the proposed introduction?

Not applicable.

e) Description of the quality assurance plan for the proposal.

Monitoring at the fishway trap in 2013 and possible associated Atlantic whitefish population work in the lakes above the dam as part of the species maintenance and recovery activities will all serve as a form of quality assurance. There is a reporting component to the work that is planned. Monitoring in the lake occurred in 2012 but no whitefish were captured from the lake so additional monitoring is planned for 2013 to determine condition factor of Atlantic whitefish. These data would be expected to be used in any evaluation subject to additional monitoring in the future.

f) What other legislative requirements are to be met?

Work is being conducted in accordance with the Fisheries Act and Species at Risk act.

H. BUSINESS PLAN / OTHER

1. Record of consultations including consideration of economic and social issues.

The consultation for the development of plans to construct the fishway and see it through to completion was through the Atlantic Whitefish Conservation and Recovery Team

(AWCRT) and a series of subcommittees and included dialogue with the appropriate officials for permitting etcetera. The DFO-Chaired AWCRT is broadly based and has continued to discuss and participate in the planning process for the opening and operation of the fishway.

I. REFERENCES

See footnotes throughout the document.

Alexander, D.R. 1973. Evaluation of the relative survival of jaw-tagged and untagged hatchery stocks of speckled trout (*Salvelinus fontinalis*) and rainbow trout (*Salmo gairdneri*) with and without fin clips and planted as fall fingerlings and spring yearlings into a Nova Scotia lake. Presented at the Can. Society of Env. Biologists, Halifax, Dec. 5, 1973. 13p.

DFO, 2004. ALLOWABLE HARM ASSESSMENT FOR ATLANTIC WHITEFISH. DFO CAN. SCI. ADVIS. SEC. STOCK STATUS REP. 2004/052.

Edge, T.A. and J. Gilhen. 2001. Updated status report on the endangered Atlantic whitefish, Coregonus huntsmani. Canadian Field-Naturalist. 1115(4): 635-651.

Bradford, R.G., D.A. Longard, and P. Longue. 2004a. Status, trend, and recovery considerations in support of an allowable harm assessment for Atlantic whitefish (*Coregonus huntsmani*). CSAS Res. Doc. 2004/109. 37 p.

Bradford, R.G., H. Schaefer, and G. Stevens. 2004a. Scope for human-induced mortality in the context of Atlantic whitefish (*Coregonus huntsmani*) survival and recovery. CSAS Res. Doc. 2004/110. 38 p.

Edge, Thomas A. 1984. Preliminary status of the Acadian Whitefish, *Coregonus canadensis*, in southern Nova Scotia. Canadian Field-Naturalist 98(1): 86-90.

J. RISK REVIEW PROCESS AND RESULTS:

In order to provide a qualitative but objective based review of the risk and mitigation options or benefits for the risks associated with passing fish through the fishway at Hebb Dam, an assessment process was adapted from the Fisheries and Oceans risk assessment framework for Science advice. Impact and likelihood are defined in that context. Biological impact is scored from 1 to 5 indicating the severity of impact and largely depends on the status of the populations considered (Appendix 2.1). The likelihood of the impact occurring is also scored from 1 to 5 indicating the relative certainty of a particular effect occurring (Appendix 2.2). The likelihood-impact risk evaluation matrix is provided in Appendix 2.3.

Table 2. Risk review perspective for fish passage for several species that may access the Petite Rivère's Hebb Lake via a fishway constructed to pass fish over Hebb Dam.

Species	Likelihood		Impact		Assessment result	Mitigation or Benefit
	Rating	Rating desc	Rating	Rating desc		
Alewife	4	Likely	3	Medium	High	The value as a food source (eggs and larvae) for Atlantic whitefish is considered to offset any potential predation by adult alewife on juvenile Atlantic whitefish. In this case, the benefit is believed to outweigh the risk.
Blueback herring	2	Unlikely	3	Medium		The value as a food source (eggs and larvae) for Atlantic whitefish is considered to offset any potential predation by adult alewife on juvenile Atlantic whitefish. In this case, the benefit is believed to outweigh the risk.
Atlantic salmon	4	Likely	1	Negligible	Moderate	1. Landlocked form: could pose a risk to whitefish; mitigation would be to prevent their passage above the dam; 2. Sea-run form adults: would pose limited risk but would have access to limited habitat above Hebb Dam. 3. Juvenile salmon would pose limited risk but would not have access to much suitable habitat. 4. Escaped farm salmon: depending on source could pose a risk to Atlantic whitefish; risk could be mitigated with prevention of passage above the dam.
Brook trout	5	Almost certain	2	Low	High	The high risk is associated with predation of brook trout on juvenile Atlantic whitefish but since the two species have co-existed for a considerable time, the risks may be overstated by this mechanism. One possible form of mitigation would be to prevent passage of brook trout that are greater than a certain size (>20cm).
Shad	1	Rare	2	Low	Low	

continued...

	Likelihood		Impact			Assesssment	Mitigation
Species	Rating	Rating desc		Rating	Rating desc	result	or Benefit
American eel	5	Almost certain		2	Low	High	American eel have cooexisted with Atlantic whitefish for an extended period. Eel are likely to pass through the fishway without selective processing in the trap. One mitigation option to the risk would be to prevent the passage of eels that are large enough to be captured in the trap.
Smallmouth bass	3	Moderate	a	3	Medium	High	Smallmouth bass will not be passed deliberately. The only mitigation for passage of small bass would be installation of a screen to limit passage of fish through the fishway trap bars and then removing those that are captured.
White sucker	3	Moderate		1	Negligible	Low	
Brown bullhead	3	Moderate	a	1	Negligible	Low	
Sea lamprey	3	Moderate	b	1	Negligible	Low	
White perch	3	Moderate		2	Low	Low	
Yellow perch	3	Moderate		2	Low	Low	

a No smallmouth bass, brown bullhead, white perch, yellow perch, or white sucker, will be deliberately passed over the dam but some fish might slip through if they are small enough to fit through the bars (½" dia. Alum. Rods spaced at 1 ¼" center to center; clear spacing in between the rods is ¾").

b Sea lamprey were a regular occurrence at the Morgans Falls fishway in the past so some could be expected on the Petite but the likelihood is somewhat uncertain.

Appendix 2.1. Degree of impact given the nature and magnitude of possible Environmental / Biological change.

Risk Area Criteria

Impact	Environmental / Biological Risks:
5. Extreme	□ Harm to an aquatic ecosystem (e.g. disease, parasites, introductions) resulting in a substantial impact on human health (e.g., domoic acid, paralytic shellfish poisoning, tsunami, oil spill). □ Species, stock or population is already threatened or endangered; further impact may lead to permanent loss. □ Permanent and spatially significant loss of critical fish habitat or ecosystem component.
4. High	□ Harm to an aquatic ecosystem (e.g. disease, parasites, introductions, invasive species) resulting in a substantial impact on human activities (including fisheries, aquaculture, tourism, infrastructure, etc.). □ Limit reference point for a stock has been reached □ A species, stock or population is assessed as Threatened, Endangered or Extirpated by the Committee on the Status of Endangered Wildlife in Canada. □ Substantial damage to fish/fish habitat that results in damage with longer term for recovery (>5 years).
3. Medium	□ A species, stock or population is under moderate pressure; further impact would result in reaching its limit reference point. □ A species, stock or population is assessed as of Special Concern by the Committee on the Status of Endangered Wildlife in Canada. □ Moderate impact to fish/habitat with medium term for recovery (3-5 years).
2. Low	□ Species, stock or population is currently stable, but additional impact could be lead to decline. □ Minor, recoverable short term changes to an aquatic species, stock or population or their habitat (e.g., seasonal or changes <1 year).
1. Negligible	□ Minimal change or impact to the species, stock, population; or minor alteration to an ecosystem in question. □ Species, stock or population is doing well; additional impact would not cause changes outside the normal range of variation. □ Habitat alteration within acceptable guidelines. □ Species, stock or population is at healthy abundance level; impacts at current level would not cause changes outside the normal range of variation.

Appendix 2.2. Scale of likelihood as described by the DFO framework.

	Description
0	Guaranteed to never occur.
1	Rare (<5%): Almost never observed – may occur only in exceptional circumstances.
2	Unlikely (5% - 24%): Has occurred infrequently before to others in similar circumstances, but not here.
3	Moderate (25% - 75%): Has occurred here before, or has been observed in similar circumstances
4	Likely (76% - 95%): Has occurred here more than once, or is occurring to others in similar circumstances.
5	Almost Certain (>95%): Occurs regularly here.

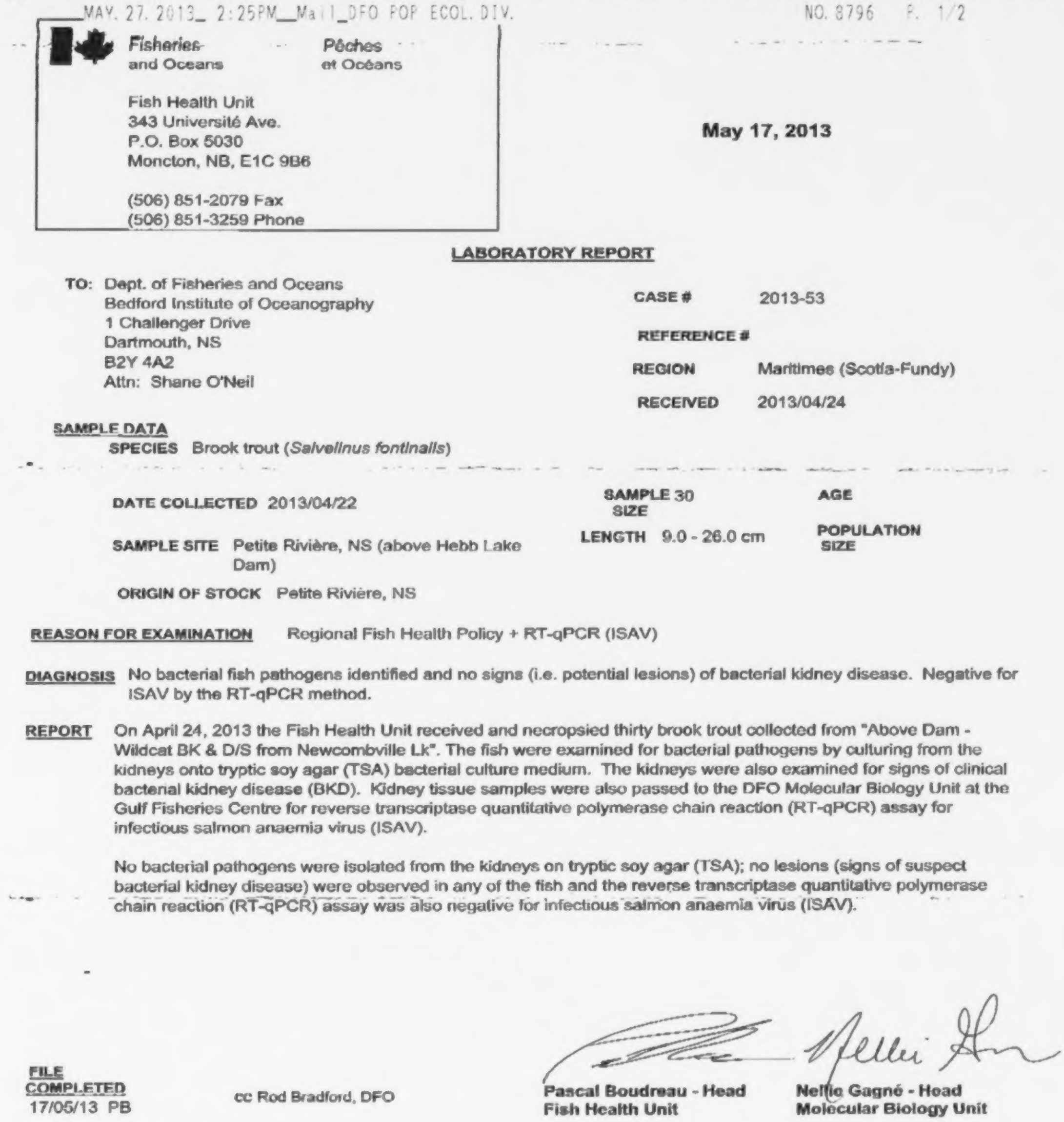
Appendix 2.3. Risk assessment results matrix.

Likelihood

Impact	1	2	3	4	5
1	Very low	Low	Low	Moderate	High
2	Low	Low	Moderate	High	High
3	Low	Moderate	High	High	Very high
4	Moderate	High	High	Very high	Very high
5	High	High	Very high	Very high	Very high

APPENDIX 3. FISH HEALTH SCREENING RESULTS

Appendix 3.1. Results of fish health screening for Brook Trout collected above Hebb Dam, April 23, 2013.



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Fisheries and Oceans
Pêches et Océans

Fish Health Unit
343 Université Ave.
P.O. Box 5030
Moncton, NB, E1C 9B6

(506) 851-2079 Fax
(506) 851-3259 Phone

May 17, 2013

LABORATORY REPORT

TO: Dept. of Fisheries and Oceans
Bedford Institute of Oceanography
1 Challenger Drive
Dartmouth, NS
B2Y 4A2
Attn: Shane O'Neil

CASE # 2013-53

REFERENCE #

REGION Maritimes (Scotia-Fundy)

RECEIVED 2013/04/24

SAMPLE DATA

SPECIES Brook trout (*Salvelinus fontinalis*)

DATE COLLECTED 2013/04/22

SAMPLE SIZE 30

AGE

SAMPLE SITE Petite Rivière, NS (above Hebb Lake Dam)

LENGTH 9.0 - 26.0 cm

POPULATION SIZE

ORIGIN OF STOCK Petite Rivière, NS

REASON FOR EXAMINATION Regional Fish Health Policy + RT-qPCR (ISAV)

DIAGNOSIS No bacterial fish pathogens identified and no signs (i.e. potential lesions) of bacterial kidney disease. Negative for ISAV by the RT-qPCR method.

REPORT On April 24, 2013 the Fish Health Unit received and necropsied thirty brook trout collected from "Above Dam - Wildcat BK & D/S from Newcombville Lk". The fish were examined for bacterial pathogens by culturing from the kidneys onto tryptic soy agar (TSA) bacterial culture medium. The kidneys were also examined for signs of clinical bacterial kidney disease (BKD). Kidney tissue samples were also passed to the DFO Molecular Biology Unit at the Gulf Fisheries Centre for reverse transcriptase quantitative polymerase chain reaction (RT-qPCR) assay for infectious salmon anaemia virus (ISAV).

No bacterial pathogens were isolated from the kidneys on tryptic soy agar (TSA); no lesions (signs of suspect bacterial kidney disease) were observed in any of the fish and the reverse transcriptase quantitative polymerase chain reaction (RT-qPCR) assay was also negative for infectious salmon anaemia virus (ISAV).

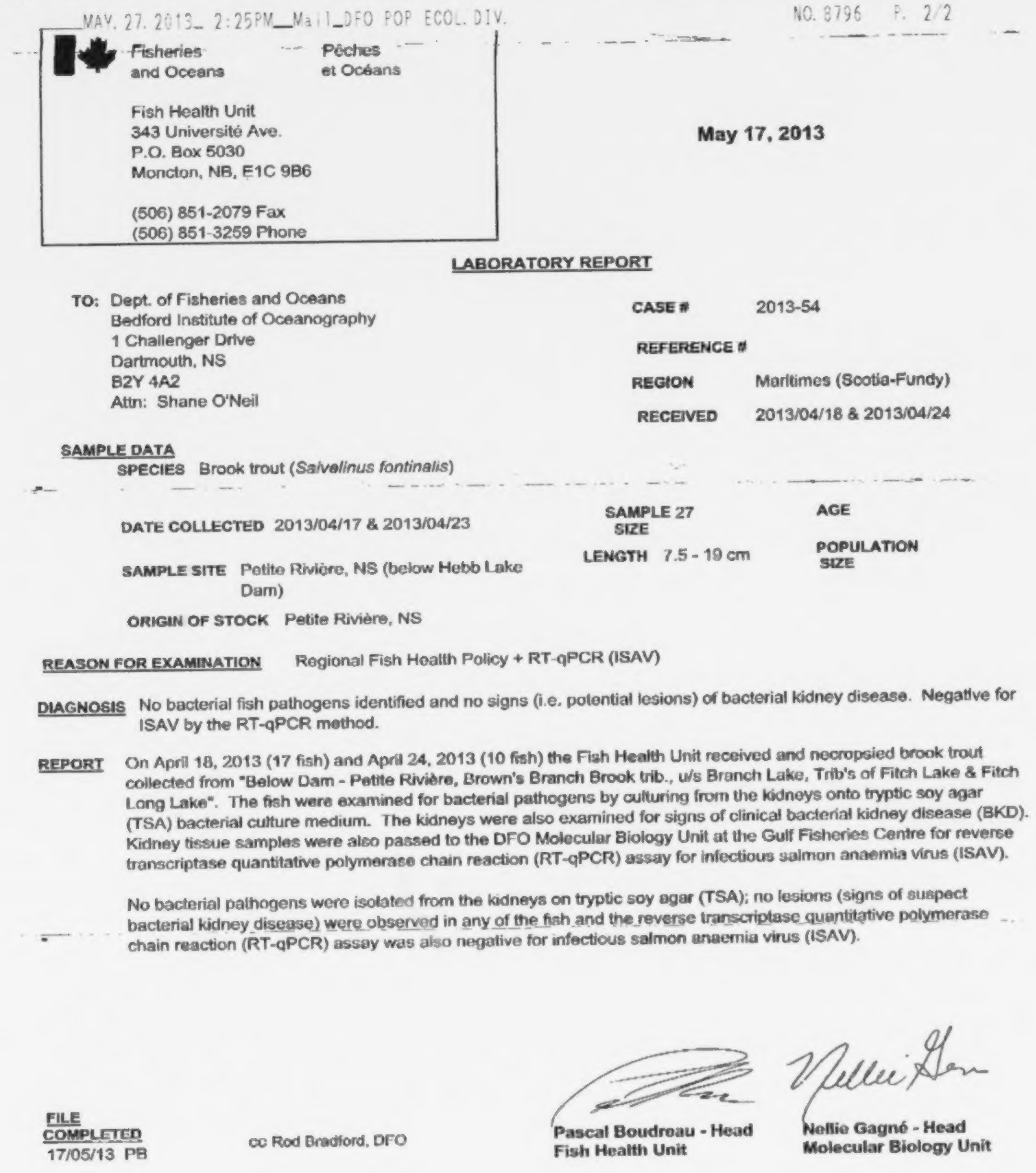
FILE COMPLETED
17/05/13 PB

cc Rod Bradford, DFO

Pascal Boudreau - Head
Fish Health Unit

Nellie Gagné - Head
Molecular Biology Unit

Appendix 3.2. Results of health screening on Brook Trout collected below Hebb Dam April 2013.



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Fisheries and Oceans Pêches et Océans

Fish Health Unit
343 Université Ave.
P.O. Box 5030
Moncton, NB, E1C 9B6

(506) 851-2079 Fax
(506) 851-3259 Phone

May 17, 2013

LABORATORY REPORT

TO: Dept. of Fisheries and Oceans
Bedford Institute of Oceanography
1 Challenger Drive
Dartmouth, NS
B2Y 4A2
Attn: Shane O'Neil

CASE # 2013-54

REFERENCE #

REGION Maritimes (Scotia-Fundy)

RECEIVED 2013/04/18 & 2013/04/24

SAMPLE DATA

SPECIES Brook trout (*Salvelinus fontinalis*)

DATE COLLECTED 2013/04/17 & 2013/04/23

SAMPLE SIZE 27

AGE

SAMPLE SITE Petite Rivière, NS (below Hebb Lake Dam)

LENGTH 7.5 - 19 cm

POPULATION SIZE

ORIGIN OF STOCK Petite Rivière, NS

REASON FOR EXAMINATION Regional Fish Health Policy + RT-qPCR (ISAV)

DIAGNOSIS No bacterial fish pathogens identified and no signs (i.e. potential lesions) of bacterial kidney disease. Negative for ISAV by the RT-qPCR method.

REPORT On April 18, 2013 (17 fish) and April 24, 2013 (10 fish) the Fish Health Unit received and necropsied brook trout collected from "Below Dam - Petite Rivière, Brown's Branch Brook trib., u/s Branch Lake, Trib's of Fitch Lake & Fitch Long Lake". The fish were examined for bacterial pathogens by culturing from the kidneys onto tryptic soy agar (TSA) bacterial culture medium. The kidneys were also examined for signs of clinical bacterial kidney disease (BKD). Kidney tissue samples were also passed to the DFO Molecular Biology Unit at the Gulf Fisheries Centre for reverse transcriptase quantitative polymerase chain reaction (RT-qPCR) assay for infectious salmon anaemia virus (ISAV).

No bacterial pathogens were isolated from the kidneys on tryptic soy agar (TSA); no lesions (signs of suspect bacterial kidney disease) were observed in any of the fish and the reverse transcriptase quantitative polymerase chain reaction (RT-qPCR) assay was also negative for infectious salmon anaemia virus (ISAV).

FILE COMPLETED
17/05/13 PB

cc Rod Bradford, DFO

Pascal Boudreau - Head
Fish Health Unit

Nellie Gagné - Head
Molecular Biology Unit

APPENDIX 4. SPECIES CAPTURED BY BOAT ELECTROFISHER

Appendix 4.1. Fish species composition at stations sampled by boat electrofishing in Petite Rivière watershed in July 2013. A. Milipsigate Lake (American Eel measured to total length (cm); all other species measured to Fork Length (cm).

Station	Attribute	Chain Pickerel	Smallmouth Bass	American eel	White Perch	White Sucker	Yellow Perch	Golden Shiner	Common Shiner	Banded Killifish	Brown Bullhead
1	Number	-	**14**	**1**	**3**	**2**	**1**	-	-		
	Mean length (cm)	-	16.5	-	17.5	26.6	-	-	-	-	-
	Length Range (cm)	-	9.5 - 20.7	-	16.5-18.2	24 - 29.1	-	-	-	-	-
2	Number	-	**9**	**1**	**3**	**3**	**5**	-	-	-	-
	Mean length (cm)	-	19.3	41	15.7	25	14	-	-	-	-
	Length Range (cm)	-	9.5 - 20.7		15.2-16.4	23.1 - 29.0	11.4 - 17.5	-	-	-	-
3	Number	**2**	**13**	**1**	-	**1**	**2**	-	-	-	-
	Mean length (cm)	17.9	18.5	37	-	28	11.1	-	-	-	-
	Length Range (cm)	7.3 - 28.4	9.8 - 25.8		-	-	9.4 - 12.7	-	-	-	-
4	Number	**6**	**10**	**1**	-	**11**	**9**	-	-	-	-
	Mean length (cm)	15.6	17.9	-	-	26.8	12.2	-	-	-	-
	Length Range (cm)	7.3 - 28.3	9.6 - 24.0	-	-	18.8 - 34.0	8.9 - 19.1	-	-	-	-
5	Number	-	**17**	-	**1**	-	**1**	**2**	-	-	-
	Mean length (cm)	-	14.4	-	19.9	-	10.6	8.4	-	-	-
	Length Range (cm)	-	9.5 - 19.2	-	-	-	-	7.2 - 9.6	-	-	-
6	Number	**2**	**31**	**13**	-	**7**	**3**	**1**	-	-	-
	Mean length (cm)	20.6	15.2	-	-	23.6	14.2	9.3	-	-	-
	Length Range (cm)	11.1 - 20.0	9.6 - 25.7	-	-	17.8 - 27.2	11.2 - 18.3	-	-	-	-
7	Number	**1**	**27**	-	**3**	**4**	**9**	-	-	-	-
	Mean length (cm)	35.6	14.4	-	12.6	26.8	8.4	-	-	-	-
	Length Range (cm)	-	7.5 - 23.5	-	12.3-12.8	25.3 - 28.4	3.8 - 13.1	-	-	-	-
8	Number	-	**18**	**2**	-	**3**	**4**	-	-	-	-
	Mean length (cm)	-	16.8	-	-	18.7	10.4	-	-	-	-
	Length Range (cm)	-	8.8 - 25.2	-	-	9.6 - 23.4	8.2 - 13.3	-	-	-	-
9	Number	-	**17**	**10**	**21**	**1**	**2**	**1**	-	-	-
	Mean length (cm)	-	21.3	-	-	26.8	13.8	9.3	-	-	-
	Length Range (cm)	-	10.5 - 40.4	-	-	-	12.6-15	-	-	-	-
10	Number	21	14	17	1	6	4	4	-	-	-
	Mean length (cm)	9.1	19.8	-	17.6	27.4	13.3	8.8	-	-	-
	Length Range (cm)	6.1-25.0	10.4 - 25.2	-	-	26 - 30.3	12.5 - 13.8	6.7 - 10.8	-	-	-

Appendix 4.2. Fish species composition at stations sampled by boat electrofishing in Petite Rivière watershed in July 2013. Minamkeak Lake (American Eel measured to total length (cm); all other species measured to Fork Length (cm).

Station	Attribute	Chain Pickerel	Smallmouth Bass	American eel	White Perch	White Sucker	Yellow Perch	Golden Shiner	Common Shiner	Banded Killifish	Brown Bullhead
11	Number	-	**27**	**1**	**3**	**4**	**11**	**1**	**1**	**1**	**1**
	Mean Length (cm)	-	18.3	-	17.1	23.9	10.9	11.2	7.7	6.6	21
	Range (cm)	-	10.0 - 25.9	-	16.0 -19.0	15.5 - 29.5	4.5 - 16.0	-	-	-	-
12	Number	-	**12**	**1**	**12**	**3**	**5**	**1**	-	-	-
	Mean Length (cm)	-	20.2	-	8.9	24.9	14.9	13	-	-	-
	Range (cm)	-	14.8 - 28.4	-	7.5 - 11.5	9.2 - 33.0	10.7 - 20.2	-	-	-	-
13	Number	-	**5**	**1**	**3**	**1**	**2**	**11**	**5**	**1**	-
	Mean Length (cm)	-	13.1	-	17.4	23	10.5	9.8	5.6 - 7.0	8.5	-
	Range (cm)	-	9.6 - 22.5	-	15.6 - 20.4	-	3.5 - 17.5	-	-	-	-
14	Number	-	**8**	-	-	**3**	**1**	**5**	-	-	-
	Mean Length (cm)	-	19.7	-	-	23.9	16	11.9	-	-	-
	Range (cm)	-	13.1 - 25.4	-	-	8.7-32.5	-	10.0 -13.6	-	-	-
15	Number	-	**9**	-	-	-	-	-	-	-	-
	Mean Length (cm)	-	15.3	-	-	-	-	-	-	-	-
	Range (cm)	-	8.9 - 22.1	-	-	-	-	-	-	-	-
16	Number	-	**3**	**1**	-	-	-	-	-	-	-
	Mean Length (cm)	-	18.4	-	-	-	-	-	-	-	-
	Range (cm)	-	16.2 - 20.5	-	-	-	-	-	-	-	-
17	Number	-	**7**	-	-	-	-	-	-	-	-
	Mean Length (cm)	-	13.1	-	-	-	-	-	-	-	-
	Range (cm)	-	8.9 - 19.5	-	-	-	-	-	-	-	-
18	Number	-	**17**	**1**	**6**	-	**3**	**1**	-	-	**2**
	Mean Length (cm)	-	14.2	-	12.5	-	11.5	13.3	-	-	22.3
	Range (cm)	-	9.3 - 23.5		9.2 - 15.5	-	9.8 - 12.6	-	-	-	22.2 - 22.4
19	Number	-	**9**	**1**	-	-	**2**	-	-	-	-
	Mean Length (cm)	-	15.5	-	-	-	12.4	-	-	-	-
	Range (cm)	-	10.8 - 20.1	-	-	-	9.6 - 15.1	-	-	-	-
20	Number	-	**5**	-	**4**	-	**4**	**3**	-	-	-
	Mean Length (cm)	-	16.4	-	11	-	12.2	7.9	-	-	-
	Range (cm)	-	13.4 - 21.3	-	9.2 - 12.5	-	9.8 - 14.3	7.7 - 8.2	-	-	-
21	Number	-	**6**	**1**	**5**	-	**13**	-	-	-	-
	Mean Length (cm)	-	15.9		14.2	-	13.1	-	-	-	-
	Range (cm)	-	13.5 - 20.6		11.6 - 15.2	-	10.2 - 16.7	-	-	-	-
22	Number	-	**10**	**1**	**3**	**3**	**3**	**1**	-	-	-
	Mean Length (cm)	-	13	-	17.1	25.6	14	10.9	-	-	-
	Range (cm)	-	9.4 - 21.4	-	15.2 - 20.5	17.1 - 33.2	11.5 - 15.7	-	-	-	-